PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

Issued *by the*

SMITHSONIAN INSTITUTION
U. S. NATIONAL MUSEUM

Vol. 105 Washington: 1955 No. 3354

THREE MIOCENE PORPOISES FROM THE CALVERT CLIFFS, MARYLAND

By Remington Kellogg

I. LOPHOCETUS PAPPUS, NEW SPECIES

During August 1933, a section of the rostrum of a porpoise that differed from the more commonly found types with elongated rostra, particularly *Eurhinodelphis* (Kellogg, 1925), *Schizodelphis* (True, 1908) and *Zarhachis* (Kellogg, 1924), was found near Governor's Run, Md. Inasmuch as Cope and Leidy had applied generic and specific names to vertebrae and teeth from the Miocene Calvert formation, it seemed desirable to await further material before an attempt was made to determine the allocation of the newly found porpoise. Fortunately, the skull, mandibles, and vertebrae of another specimen were located in July 1939. A critical examination of the vertebrae and teeth has convinced the writer that this form is not represented among the types of previously described porpoises deposited in the Academy of Natural Sciences of Philadelphia.

Although the affinities of the Miocene *Lophocetus* are somewhat uncertain, the conformation of the skull and the relationships of its componental bones suggest that it is rather closely allied to the Iniidae. The periotic bones of both *Inia* and *Lipotes* are highly modified and exhibit slight resemblance to one another in outward appearance. The periotic of *Lophocetus* differs in many details from that of either of these Recent genera.

338378—55——1

Porpoises now allocated to the family Iniidae were well represented and widely distributed during the Miocene and Pliocene. Nevertheless, the two known living forms are widely separated geographically, the South American *Inia geoffrensis* being restricted to the Amazon and the Orinoco Rivers and their larger tributaries, and the Chinese *Lipotes vexillifer* being known only from Tung Ting Lake, Yangzte River. Both of these Recent genera are confined to fresh water. During the Miocene and Pliocene, some at least were inhabitants of estuaries and others presumably were part of the pelagic fauna.

Genus *Lophocetus* Cope

Lophocetus Cope, Proc. Acad. Nat. Sci. Philadelphia, vol. 19, pp. 144, 146, December 1867.

GENOTYPE: *Delphinus calvertensis* Harlan.

DIAGNOSIS: Skull strongly constructed, rostrum (389 mm.) equivalent to not more than three-fifths of the length of the skull (estimated 630 mm.); vertex of skull elevated, elongated and comprised by the large nasal bones, the exposed posterointernal angles of the frontal bones and the apex of the supraoccipital; nasals large, elongated anteroposteriorly and deeply depressed internally; no pronounced thickening of supraorbital processes of frontals and overlying maxillary plates; zygomatic processes elongated and relatively slender; rostrum attenuated toward anterior extremity, with distal one-third slightly bent upward; mesorostral gutter on anterior one-half of its length roofed over by close approximation of premaxillaries; posterior end of each premaxillary upturned, forming an oblique crest, and is pinched-in externally below crest; maximum transverse expansion of premaxillaries immediately in front of nasal passages; 3 teeth located in distal end of each premaxillary; 23 to 24 teeth located in each maxillary; large lachrymal wedged in against preorbital portion of supraorbital process and overlying ascending plate of maxillary, the anteroposterior diameter apparently greater than transverse; jugal ankylosed to lachrymal; palatines extending forward almost to level of hindmost alveolae.

Mandibles robust, with symphysis equivalent to one-third of the length of each ramus; symphysis ankylosed, slightly narrowed at anterior extremity, semicircular in cross section anteriorly, and with anterior half of its length bent upward; lateral surfaces of symphysis rugose; opposite free hinder portions of mandibles form an acute angle at level where they ankylose as symphysis; 26 teeth in each mandible; 14 teeth located on each mandible posterior to hinder end of symphysis; 12 teeth located on each ramus anterior to hinder end of symphysis; roots of teeth on symphysis implanted obliquely in alveolae, which

slope more backward than inward; diameters of alveolae diminish more markedly toward hinder end of tooth series than anteriorly.

Lophocetus calvertensis (Harlan)

Delphinus calvertensis Harlan, Bull. Proc. Nat. Inst. Promotion Sci. Washington, No. 2, pp. 195–196, 1842.

Type specimen (USNM 16314): Incomplete skull, lacking both zygomatic processes as well as supraorbital processes of frontals and distal end of rostrum; left periotic; atlas, axis, third, fourth, fifth, sixth, and seventh cervical and first and second dorsal vertebrae. Collector, Francis Markoe, Jr., October–November 1841.

Horizon and locality: Cove Point, Calvert County, Md. St. Marys formation.

Lophocetus pappus, new species

Figure 1; Plates 1–11

Individual 1

Type specimen (USNM 15985): Skull which lacks basicranium, occipital condyles, supraoccipital, right squamosal and right zygomatic process; right and left mandibles; 75 detached teeth; left periotic; right tympanic bulla; atlas; 3 cervicals; 4 dorsals; and portions of 10 ribs. Collector, A. C. Murray. July 9, 1939.

Horizon and locality: In compact sandy blue clay of Zone 11 (1 foot below base of Zone 12), about 8 feet above base of cliff, approximately nine-tenths of a mile north of mouth of Parker Creek, Calvert County, Md. Calvert formation, upper Miocene.

Individual 2

Referred specimen (USNM 20659): Section of rostrum (225 mm. in length), basal portion of left scapula, anterior dorsal vertebra (incomplete), terminal caudal, and right periotic. Collectors, Remington Kellogg, C. Lewis Gazin, and Raymond M. Gilmore, Aug. 17, 1933.

Horizon and locality: In sandy clay of Zone 14 (about 3 feet above contact with Zone 13), approximately 956 yards north of old pier at end of Governor's Run Road (see U. S. Geol. Surv. Prince Frederick Quad.), Calvert County, Md. Calvert formation, upper Miocene.

SKULL

Aside from differences in the conformation of the nasal bones, and the amount of exposure of the frontals on the vertex, the skull of *Lophocetus pappus* seems to differ from that of *Lophocetus calvertensis*

(Case, 1904, pp. 26–27, pl. 16) chiefly in the slightly larger dimensions. The St. Marys porpoise has slightly longer and more elevated nasal bones, a narrower vertex, and a more deeply depressed maxillary on each side of the vertex.

Dorsal view: The skull (pl. 1) of this porpoise differs markedly from those of all porpoises previously described from the Calvert formation. Some resemblance to *Diochotichus vanbenedeni* (Moreno, 1892, pl. 11; True, 1910, pl. 1) and *Squalodelphis fabianii* (Dal Piaz, 1916) is exhibited by this skull, but it can be distinguished readily from the former by the absence of a pair of foramina for the olfactory nerves on the posterior wall of the nasal passages, by the elongated vertex composed of the nasal bones and the exposed posterointernal angles of the frontals, by the absence of any pronounced thickening of the supraorbital processes and the overlying maxillary plates, by the shape of the relatively slender zygomatic processes, and by the greater number of teeth.

The form of the rostrum is somewhat similar to that of *Squalodon* (Kellogg, 1923, pl. 1), the widest portion being at the level of the antorbital notches. The lateral swelling at the base of the rostrum extends forward for a distance of about 70 mm. beyond the antorbital notches. In an interval of 130 mm. the rostrum diminishes in width from 105 mm. to 48 mm.; the attenuation of the slightly longer terminal portion of the rostrum is more gradual. The narrow antorbital notches are bounded externally by the lachrymal and by the preorbital apophysis of the overlying maxillary.

The premaxillaries are more or less flattened on the basal portion of the rostrum, but become more convex anterior to the level of the hinder end of the tooth row. Near the distal end of the rostrum, the outer surface of each premaxillary slopes steeply from the inner to the outer margin. The inner margins of the opposite premaxillaries seem to have been in contact for a distance of about 20 mm. in front of the nasal passages, and after spreading slightly apart gradually converge at a point 150 mm. distant and then, closely approximated, parallel one another to the extremity of the rostrum. The convex portion of each premaxillary commences to widen transversely at about the level of the antorbital notches and attains its maximum width on the rostrum at about the level of the penultimate alveola. Behind the level of the antorbital notches, the premaxillaries exhibit the maximum transverse expansion in front of the nasal passages. Opposite the nasal passages each premaxillary is noticeably elevated above the corresponding maxillary, the convex outer portion sloping to the line of sutural contact with the latter. The posterior end of each premaxillary is upturned, forming an oblique crest, and is

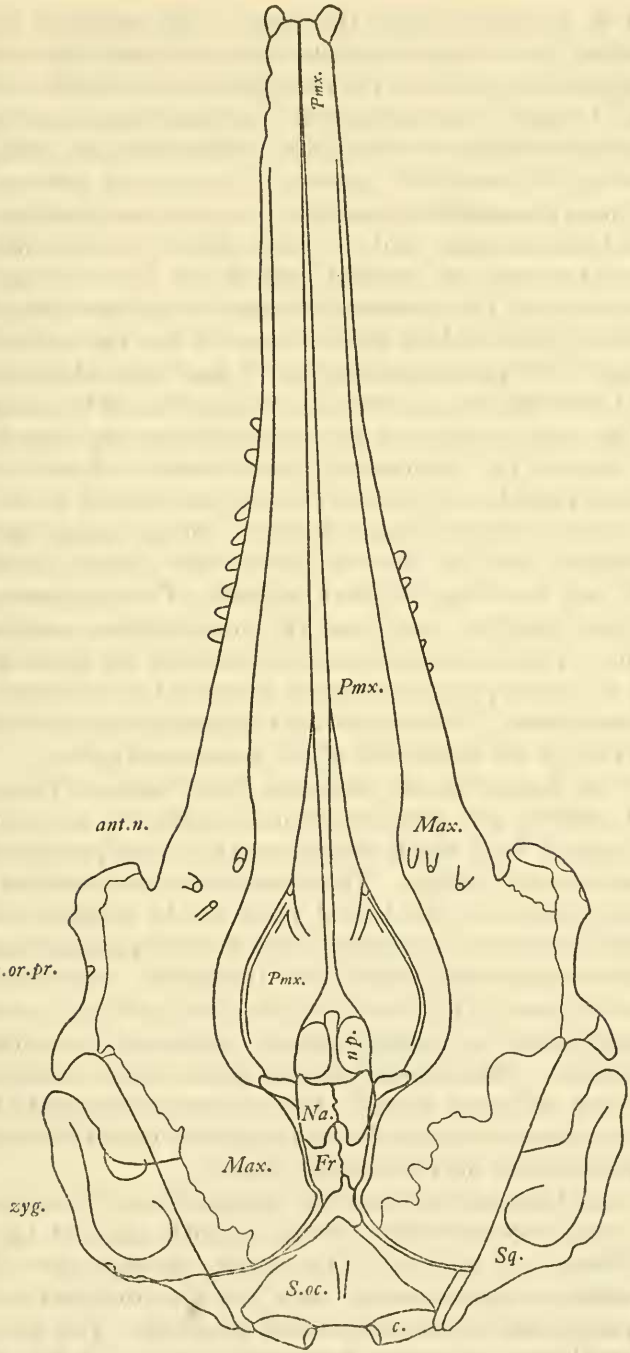

FIGURE 1.—Dorsal view of skull of *Lophocetus pappus*, with restored posterior end of brain-case. Abbreviations: ant. n., antorbital maxillary notch; c., occipital condyle; Fr. frontal; Max., maxillary; Na., nasal; np., nasal passage; Pmx, premaxillary; Sq., squamosal; S.oc., supraoccipital; s.or.pr., supraorbital process of frontal; zyg., zygomatic process.

pinched in externally below this crest. The posterior end of each premaxillary is in contact with the upturned inner edge of the corresponding ascending plate of the maxillary and internally for a distance of about 15 mm. abuts against the corresponding nasal bone. The premaxillary foramina are elongated and are situated slightly behind the level of the antorbital notches. Two narrow grooves lead from each of these premaxillary foramina, the outer one extending obliquely backward and outward, and the inner shorter one curving backward and inward to near the internal edge of this bone. Commencing at about the level of this premaxillary foramen and extending backward is a shallow groove which follows more or less the curvature of the outer edge of the premaxillary about 14 mm. inside the latter.

With the exception of a short interval in front of the nasal passages where the inner margins of the premaxillaries are almost if not in actual contact, the mesorostral gutter seems to have been almost completely roofed over by the close approximation of the opposite inner margins of these elongated bones. On the distal 230 mm., the premaxillaries meet on the midline of the palatal surface of the rostrum, and constitute the floor and sides of the mesorostral gutter; behind this point the vomer and the premaxillaries contribute to its formation. The vomer increases in width from its anterior end to in front of the nasal passages where it is applied to the lateral surfaces of the presphenoid. The presphenoid appears to be rather porous and forms a plug at the hinder end of the mesorostral gutter.

As in the Recent South American river porpoise *Inia geoffrensis* (USNM 239667, ♂), the mesethmoid is limited to the median longitudinal strip of bone which constitutes the dorsal portion of the wall between the nasal passages. The mesethmoid also sheathes the dorsal and upper halves of the lateral faces of the laterally compressed presphenoid and on the inner wall of each nasal passage meets edge to edge the corresponding wall of the troughlike vomer in which the presphenoid rests. All traces of sutures that mark the contact of the mesethmoid with the laterally placed ectethmoids have disappeared with ankylosis. These fused ethmoid bones form a continuous sheet of bone, now destroyed dorsally, that overspread the ventral halves of the anterior faces of the nasals and completely closed the area through which the olfactory nerves formerly passed.

A U-shaped anterior border of the combined nasal passages is formed by the close approximation of the internal edges of the opposite premaxillaries. At the level of the vertex, the posterior wall of each nasal passage is approximately on a line with the ends of the postorbital projections of the supraorbital processes. The posterior wall of each nasal passage does not descend obliquely as in *Inia*, but about

half way in its height is deflected forward horizontally in consequence of the bulging forward of the anterior wall of the braincase, and then drops almost vertically to the interpterygoid space. The shelf that is thus formed in each passage some 25 mm. below the level of the premaxillary on the anterior rim is approximately equivalent in size to the circumference of the corresponding nasal passage; the almost vertical lower portion of each passage is for the most part hidden when viewed from above.

The maxillaries and premaxillaries constitute the major portion of the dorsal surface of the skull. For a distance of 30 mm. in front of the antorbital notch, the outer border of the maxillary is compressed dorsoventrally and also is concavely depressed dorsally in the region between the antorbital notch and the maxillary foramina. Immediately in front of this basal swelling, the maxillary from a side view abruptly increases in dorsoventral diameter, the convex curvature of the upper surface becomes flattened, and the slope from the premaxillary-maxillary suture gradually becomes steeper. As a result of the attenuation of the rostrum, the maxillary decreases in breadth and depth anteriorly, and is barely visible from a dorsal view near its distal end. Posterior to the antorbital notch, the maxillary expands horizontally and overspreads the frontal bones. This thin ascending maxillary plate, however, does not completely sheath the supraorbital process of the frontal, a strip of the outer border of the latter 10 to 17 mm. in width being exposed above the orbit. In front of the orbit and external to the antorbital notch, the anteroexternal angle of the ascending plate of each maxillary is produced, forming an apophysis, which overspreads the underlying enlarged lachrymal bone. This flattened lachrymal bone is actually wedged in between the preorbital portion of the supraorbital process and the overlying ascending plate of the maxillary. The maximum width of the ascending plate of the maxillary seems to have been attained at the level of the antorbital notch, but this is uncertain in view of the apparent incompleteness of the outer border of the ascending plate of both maxillaries (fig. 1) above the temporal fossae. The posterior borders of the maxillaries are thrust backward against the curved dorsal crest of the supraoccipital and consequently the posterointernal border of each maxillary is bent upward for a height of approximately 22 mm., the dorsal edge projecting slightly above the level of the posterointernal angles of the frontals, which are exposed on the vertex. The thin and transversely curved ascending plates of the maxillaries and the corresponding underlying lateral extensions of the frontals probably did not completely roof over the temporal fossae (fig. 1). As regards curvature, each maxillary is

strongly depressed behind the level of the nasal passages and there is also a concave depression on each behind the level of the center of the orbit. Although the outer border of the ascending plates of both maxillaries are incomplete, there is no indication from the curvature of the portions preserved that these plates were bent upward externally as in the case of *Inia*. Two large and one small foramina, that connect with the infraorbital system, are present in each maxillary at about the level of the antorbital notches.

From a dorsal view the frontals are largely concealed by the overspreading ascending plates of the maxillaries, the slender posterior ends of the premaxillaries, and the nasals. They are suturally united posteriorly with the supraoccipital. Medially, the opposite frontals meet edge to edge on the vertex, constituting a subscutiform area with apex forward. The vertex is elevated, relatively small in area, quadrangular in outline, and is constituted posteriorly by the posterointernal angles of the frontals and anteriorly by the nasals. Laterally, each frontal sends out a thin platelike extension which underlies at least in part the horizontally expanded ascending plate of the maxillary. Further forward, this portion of the frontal is considerably thickened to form a complete osseous roof for the orbit.

The nasals are rather large and irregular in shape; they constitute the upper portion of the posterior wall of the nasal passages. Dorsally, the nasals are deeply excavated internally, the surface of each sloping obliquely downward from the rounded outer border to the midline. Anteriorly, the posteroexternal angle of each is prolonged forward. The vertical diameter of the right nasal near the anterior end is 22.5 mm.

Lateral view: Aside from the rather robust rostrum and the relatively low vertex, the skull as viewed from the side (pl. 2, fig. 1) is characterized by a relatively small braincase, by the small orbit, by the laterally flattened and upwardly curved zygomatic process, and by the presence of 26 to 27 robust teeth in each upper jaw, of which 3 are lodged in the premaxillary. A tooth slightly larger than the others projects forward and downward from the extremity of the premaxillary. In *Inia geoffrensis*, the anteriormost tooth in the premaxillary is almost vertical. At the base the depth of the rostrum is approximately one half the corresponding width. For approximately 30 mm. in front of the antorbital notch, the ventral surface of the maxillary slopes downward and backward from the outer margin, and the upper surface slopes from the premaxillary-maxillary suture to the outer edge. The basal swelling on the dorsal surface of the maxillary that extends forward about 70 mm. in front of the antorbital notch is rather strongly convex. Beyond this basal section,

the upper surface of the maxillary slopes from the premaxillary suture to the alveolar margin, becoming steeper anteriorly as the maxillary decreases in depth, and near its extremity is almost vertical. Near the middle of the rostrum (the 14th alveola counting forward) the dorsolateral face of the maxillary has approximately the same depth as that of the premaxillary, but from this point forward it gradually diminishes in height while the premaxillary increases. The extremity of the rostrum is formed entirely by the premaxillaries. From a lateral view the alveolae are visible for most of the length of the tooth row, the hindermost alveola being located 52 mm. in advance of the antorbital notch. The terminal 100 mm. of the rostrum is bent slightly upward, and the basicranial axis is bent downward from that of the rostrum.

At approximately the level of the 16th alveola counting forward, a small foramen is located in the premaxillary-maxillary suture from which a shallow groove extends forward about 3 mm. above the latter on the lateral face of the premaxillary and disappears about 55 mm. behind the extremity of the rostrum. On the terminal 160 mm. of both premaxillaries are a number of small scattered nodules about 2 mm. in diameter and shallow grooves which suggest that the end of the rostrum may have been covered with close-fitting tough skin.

The dorsal surfaces of the nasal bones are the highest points on the dorsal profile. From the anterior ends of these bones to and slightly beyond the anterior end of the presphenoid, the premaxillaries slope strongly downward. The depressed maxillaries, however, slope more gradually from the transverse crest of the supraoccipital to the base of the rostrum.

On its external border, the supraorbital process of the frontal is rather thin. The anterior angle or preorbital projection is a slight enlargement, about 20 mm. in depth, but the posterior angle or postorbital projection is prolonged downward, forming a slender process which seemingly did not come in contact with the zygomatic process. The maximum anteroposterior diameter of the left supraorbital process is 90 mm., and the corresponding diameter of the orbit is 60 mm.

The flattened lachrymal bone, whose anteroexternal diameter is 43 mm. on the right side, is closely appressed to the anterior face of the supraorbital process and is overspread by the anteroexternal angle of the ascending plate of the maxillary, its narrowed inner end being wedged in against the supraorbital process and the maxillary.

The slender styliform process of the jugal that extends below the orbit from the antorbital notch to the anterior face of the zygomatic process is missing.

Originally, the temporal fossa seems to have been relatively short (120± mm.) and high (90± mm.), and it is apparent that its length

was at least twice that of the orbit. Superiorly, the temporal fossa is bounded by the thin platelike lateral extension of the frontal that underlies the platelike ascending process of the maxillary; and presumably posteriorly the temporal fossa is bounded by the lambdoid crest that follows the lateral margin of the supraoccipital. In this fossa, the parietal is united anteriorly and superiorly with the frontal, posteriorly with the supraoccipital, and inferiorly with the squamosal. There is no evidence that the parietal participated in the formation of the vertex.

As compared with that of *Inia geoffrensis*, the laterally flattened zygomatic process is shorter and less robust; it is thickened dorsoventrally and its anterior extremity is obliquely truncated. The ventral margin is regularly curved and the postglenoid process is relatively short. The greatest length of the left zygomatic process on its articular face is 81 mm. and the greatest depth at its anterior extremity is 28 mm.

Ventral view: The ventral surface of the rostrum (pl. 3) is formed mainly by the maxillae, which meet mesially at the level of the anterior margins of the palatines and continue forward in contact for a distance of 60 mm. and then for an interval of 75 mm. are separated by the axial ridge of the vomer. Behind the level of the 10th alveolae counting backward from the first, the maxillae increase in width markedly toward the antorbital notches, the palatal surface becoming increasingly convex. The ventral orifice of the infraorbital canal is located in the maxilla internal to the inner end of the lachrymal. There were 24 teeth in the right maxilla, 23 in the left maxilla, and 3 in each premaxilla.

On each side of the palate the presence of a thin groove, commencing at the level of the anterior end of the ventral axial ridge of the vomer and extending forward to the fourth alveola counting backward from the first, suggests that a narrow strip of each premaxilla, 6 mm. in width anteriorly and 4 mm. posteriorly, may have separated the maxillae on the distal portion of the rostrum.

The dorsoventrally flattened lachrymal is wedged in against the maxilla and the supraorbital process of the frontal and is partially overspread ventrally by a thin plate of the latter. Ventrally, the lachrymal externally and the jugal internally contribute to the formation of the antorbital notch.

The basal portion of the jugal on the left side is preserved, and it is so intimately ankylosed to the large lachrymal bone that the exact limits of these two bones cannot be determined. The slender styliform process of the left jugal, however, was not found.

The basicranium and the lateral walls of the braincase are missing; consequently, accurate comparisons cannot be made. The relations and structural peculiarities of the pterygoids and palatines in the region of the narial passages appear to correspond more closely to *Inia* than with other recent porpoises.

Each palatine bone is mortised into the ventral surface of the corresponding maxilla and posteriorly overspreads the ventral trough of the vomer, forming the internal surface of the triangular depression in front of the corresponding narial passage. The broken edges of the palatine on each side suggest that a thin external plate of this bone partially, at least, may have overspread this depression. The palatines extend forward almost to the level of the hindmost teeth.

On the palatal surface, the lateral wall, at least, and also probably the ventral wall, of the ventral portion of each narial passage were formed by the pterygoids.

The hinder portion of the vomer, which normally widens horizontally and sheaths the basisphenoid behind the narial passages, is destroyed. Externally on each side the vomer meets the pterygoid edge to edge and contributes the internal and anterior surfaces of each narial passage.

On the left side the squamosal is suturally united with the lower border of the parietal and its lateral projection or zygomatic process forms the articular surface for the lower jaw. The glenoid articular surface on the ventral face of the zygomatic process is strongly concave, curving upward and forward. The external border of the glenoid facet follows the outer curvature of the zygomatic process, but the external border of at least the posterior half of this surface is set off by a deep groove on the squamosal that undercuts the internal and posterior borders of the facet. The posterior half of the glenoid facet is noticeably widened, and the anterior half is progressively narrowed toward the extremity of the zygomatic process.

Posterior view: With the exception of the left zygomatic process, the adjoining portion of the squamosal, and the apex of the supraoccipital, all of the posterior wall of the braincase is missing.

The referred speciman (USNM 20659) consists of a distal section of the rostrum (pl. 11, fig. 1) of a smaller individual measuring 225 mm. in length. Comparison with the skull suggests that the two anteriormost pairs of alveolae are missing on this rostral fragment, since the groove on the lateral surface below the premaxillary disappears at about the level of the third pair of alveolae counting backward from the extremity. On the left side, eight alveolae occupy an interval of 122 mm.

MEASUREMENTS OF SKULL (IN MILLIMETERS)

	Lophocetus pappus (USNM 15985)	Lophocetus calvertensis (USNM 16314)
Greatest length (occipital condyles to extremity of rostrum, as preserved)		374.+
Apex of supraoccipital to extremity of rostrum, as preserved	563. 0	315.+
Posterior end of ascending plate of left maxillary to extremity of rostrum	567. 0	342.+
Length of rostrum (level of maxillary antorbital notches to extremity of rostrum)	389. 0	
Breadth of rostrum at base (between maxillary antorbital notches)	154. 0	
Breadth of rostrum at level of anterior margins of alveolae of 15th pair of teeth (counting forward)	45. 5	
Breadth of rostrum 25 mm. behind anterior end	30. 0	
Length of left zygomatic process (postglenoid process to extremity)	83. 5	
Height of skull (basisphenoid to nasals)		140. 0
Greatest breadth of skull across preorbital angles of supraorbital processes	238. 0	
Greatest breadth of skull across postorbital angles of supraorbital processes	254. 0	
Apex of supraoccipital to anterior margin of left nasal	49. 0	49. 0
Posterior end of ascending plate of left maxillary to level of hinder wall of nasal passages	80. 0	83. 0
Distance between outside margins of premaxillaries at level of anterior margins of nasal passages	107. 0	107. 0
Greatest breadth of right premaxillary in front of nasal passages	51. 0	53. 0
Greatest breadth of left premaxillary at maxillary antorbital notch	31. 0	
Length of frontal plate of left maxillary	174. 0	
Distance between inner margins of maxillaries at vertex	28. 0	23. 0
Greatest anteroposterior diameter of left supraorbital process	90. 0	
Greatest length of exposed portion of frontal on vertex		27. 0
Greatest anteroposterior diameter of right nasal	25 0	40. 5
Transverse diameter of right nasal	16. 5	20. 0
Greatest transverse diameter of the two nasals	33. 5	42. 5
Least breadth of cranium between temporal fossae		120. 0

Greatest breadth of braincase across parietals		134. 0
Distance from apex of supraoccipital to upper margin of foramen magnum		118. 0
Height of foramen magnum		33.±
Width of foramen magnum		32. 0
Greatest distance between outside margins of occipital condyles		95. 0
Greatest height of right condyle		50. 0
Greatest breadth of right condyle		38. 0
Right upper jaw, 27 alveolae in an interval of	360. 0	
Left upper jaw, 25 alveolae in an interval of	353. 0	
Left maxillary, 1st to 9th alveola (counting forward)	93. 0	86. 5
Right maxillary, 1st to 15th alveola (counting forward)	161. 0	
Left maxillary, 14th to 23d alveola (counting forward)	162. 0	
Left maxillary, anteroposterior diameter of 23d alveola	14. 0	
Distance between inner margins of alveolae of hindmost teeth in opposite maxillaries	96. 5	80. 0
Distance between inner margin of 15th alveola in right maxillary and 14th alveola in left maxillary (counting forward)	31. 0	
Distance from right antorbital notch to posterior margin of hindmost alveola in right maxillary	50. 5	

The outer surface of the premaxillary is convex and the maxillary increases in depth anteroposteriorly as on the skull. The relations of the bones comprising the ventral surface of this rostral fragment correspond rather closely with those noted on the skull.

MANDIBLES

The mandibles (pl. 4) of this fossil porpoise exhibit many of the characteristic inid features, including the firmly ankylosed symphysis. They differ from those of *Inia geoffrensis* by having a relatively shorter symphysis, a more gradual slope from the vertex of the coronoid process to the hindmost alveola, and more than twice the number of teeth situated behind the level of the hinder end of the symphysis.

On these fossil mandibles the symphysis is equivalent to 33 percent of the length of the left ramus in contrast to 57 percent for *Inia*. The symphyseal portion of the mandibles as well as the interval between the tooth rows are relatively wider than in *Inia*, and the anterior

half of the symphysis curves distinctly upward in contrast to the general downward slope of the corresponding portion of the mandibles of *Inia*. The anterior end of the symphysis is obliquely truncated in a dorsoventral direction. The opposite free posterior portions of the mandibles come together at a 28-degree angle at the symphysis.

About 61.5 percent of the total length of the left mandible is occupied by the tooth row in contrast to 66 percent for *Inia*. The number of alveolae, however, is approximately the same in these fossil and Recent porpoises. The fossil mandibles have 26 alveolae in each ramus, the five alveolae at the anterior end of each ramus being somewhat larger than the others. The tendency toward the anteroposterior elongation of the alveolae in the symphyseal region, so noticeable in *Saurocetes argentinus* (Rovereto, 1915, pl. 2, fig. 1; Burmeister, 1871) and to a lesser degree in *Goniodelphis hudsoni* (Kellogg, 1944, pl. 1, fig. 1; Allen, 1941), is hardly discernible. The alveolae in the left mandible measure from 8 to 15 mm. anteroposteriorly and from 8 to 12 mm. transversely. The 17 alveolae on the hinder portion of each mandibular tooth row are separated by rather thin septa, while those situated near the middle of the symphysis are separated by intervals of 5 to 7 mm. The presence of 14 teeth in each ramus behind the level of the hinder end of the symphysis readily distinguishes these mandibles from those of *Inia geoffrensis* (USNM 49582). As a result of the lengthening of the symphysis on the mandibles of *Inia*, there are only 5 teeth in the left ramus and 6 teeth in the right ramus posterior to the hinder end of the symphysis, although there are 27 teeth in each mandible.

Opposite alveolae at hinder end of symphysis are separated by an interval of 26 mm.; the corresponding interval between the 25th alveolae (counting forward from hindmost) is 11 mm. The symphysis is semicircular in cross section.

On the outer surface of the left mandible (pl. 4, fig. 2), and about 16 mm. below the rim of the ninth alveola (counting forward from the hindmost) is a foramen of moderate size. The next external nutrient foramen is smaller and is located about 14 mm. below the septum separating the 15th and 16th alveolae. Two small foramina, one situated above the other, are located 10 mm. below the rim of the 19th alveola. The anteriormost foramen is located 17 mm. below the rim of the 21st alveola. From each of these alveolae shallow grooves of varying lengths extend forward. The anterior 175 mm. of the outer surface of the left ramus is quite rough and nodular, indicating that at least this portion of the ramus was covered with a tight-fitting skin.

The conformation of the posterior portions of the mandibles of this fossil porpoise insofar as preserved are somewhat similar to

that of *Inia*. The dorsal border of the coronoid process is thickened as in *Inia*. The distance from the apex of the coronoid process to the hindmost alveola on the left ramus, however, amounts to about 30.5 percent of the total length, while in *Inia* it is equivalent to about 23.5 percent of the total length. The external face of the posterior end of the left mandible is convex except for the shallow concavity below the apex of the coronoid process. The dorsoventral axis of the condyle is oblique, and its external border is projected beyond the level of the outer face of the ramus.

About 35 mm. behind the hindmost alveola and on the internal surface of the ramus is the usual orifice for the large dental canal. Posterior to this orifice the proximal end of the ramus consists mainly of a thin outer shell, with the addition of thin internal shelving strips that merge posteriorly with the upper and lower borders.

MEASUREMENTS OF MANDIBLES, USNM 15985 (IN MILLIMETERS)

	Right	Left
Length of mandible, condyle to anterior end		540. 0
Length of mandible as preserved, anterior end to broken hinder end	520. 0	
Greatest length of ankylosed symphyseal portion of rami	179. 0	179. 0
Transverse diameter of ankylosed mandibular symphysis at level of hinder end	55. 0	
Vertical diameter of ankylosed mandibular symphysis at level of hinder end	32. 2	
Transverse diameter of ankylosed mandibular symphysis at anterior end	33. 8	
Vertical diameter of ankylosed mandibular symphysis at anterior end	22. 0	
Height of mandible through coronoid process	82. 0+	98. 0
Height of condyle		36. 5
Breadth of condyle		37. 8+
26 alveolae in an interval of	328. 0	332. 0
14 hinder alveolae (1st to 14th) in an interval of	156. 0	152. 0
12 anterior alveolae (15th to 26th) in an interval of	170. 0	180. 0

PERIOTIC

The left periotic (pl. 5, figs. 1, 4) differs from that of *Lophocetus calvertensis* (pl. 5, figs. 3, 6; USNM 16314) in that there is no osseous projection below the cerebral orifice of the aquaeductus vestibuli, the dorsoventral diameter of the extremity of the anterior process is considerably less, the fossa for the head of the malleus is less vertical in position, the anteroposterior diameter of the less noticeably inflated pars cochlearis is considerably less, and the depression on the

anterior process for the reception of the uncinate process of the outer lip of the bulla has a somewhat different conformation.

The articular facet on the ventral surface of the posterior process is incomplete on all sides. This facet is shallowly concave on the basal half and the articular surface slopes from the outer to the anterior margin. Two low ridges extending from the outer to the inner margin are present on the hinder half of this facet. The anterior face of the posterior process is excavated; the external face has been sheared off; and the posterior face is irregular in contour.

As regards the ventral aspect of the pars cochlearis, the resemblance to *Lophocetus calvertensis* is not very close, since the latter is noticeably larger and the curvature of this surface is more regularly convex. The facet for the accessory ossicle or uncinate process of the tympanic bulla on the ventral surface of the anterior process is deeply concave and is limited internally by a deep narrow groove. The fenestra rotunda is roughly subtriangular in outline and larger than the fenestra ovalis. The foot plate of the stapes completely fills the ovoidal fenestra ovalis and is held in position by narrow internal ledges on the anterior and posterior walls. Within the fenestra ovalis are the orifices of the small semicircular canals that open into a circular depression in the vestibule opposite to the epitympanic orifice of the aquaeductus Fallopii; a larger orifice situated at the posterointernal angle of the vestibule is the terminus of the aqueduct leading from the foramen rotundum and the scala vestibuli.

The epitympanic orifice of the aquaeductus Fallopii is small and the narrow groove for the facial nerve, which leads from it, is definitely limited by the thin rim of the fenestra ovalis and the projecting ledge formed by the internal margin of the fossa for the head of the malleus, but posterior to these structures its course along the internal and posterior faces of the posterior process is less sharply defined. The elongate fossa for the stapedial muscle, which is located in a depression behind the fenestra ovalis and internal to the groove for the facial nerve, is rather deep and somewhat rugose. Along the internal margin of the stapedial fossa a low thin-edged crest is developed on the ventroexternal angle of the pars cochlearis, which extends backward to the base of the posterior process. The depth of the posterior face of this periotic (11.5 mm.), as measured from the stapedial fossa to the dorsal face above the cerebral orifice of the aquaeductus vestibuli, is somewhat less than the corresponding measurement of the periotic of *Lophocetus calvertensis* (12.1 mm.).

Between the rounded tuberosity or swelling, on which the fossa for the head of the malleus (pl. 5, fig. 1) is located, and the anterior margin of the articular facet on the posterior process the ventral surface of the

external denser portion of the periotic is deeply excavated, but is almost shut off internally from the epitympanic recess by a thin osseous crest which constitutes the external boundary of the small fossa incudis. The fossa incudis, which receives the crus breve of the incus, is shallowly concave anteriorly and terminates in a small deep pit on the anterointernal angle of the posterior process.

The anterior process is compressed from side to side, almost triangular in cross section and is bent inward, terminating in a ventral, upwardly curved point. The main articular surface on the anterior process for the accessory ossicle or uncinate process of the tympanic bulla is elongated and concavely curved in an anteroposterior direction. This articular area occupies more than half of the ventral surface of the anterior process. A fingerlike osseous projection, which arises between the pars cochlearis and the narrow deep groove which marks the internal limit of the facet for the above-mentioned accessory ossicle, is no doubt fortuitous.

The cerebral face of the pars cochlearis (pl. 5, fig. 4) is broken off, exposing the scala vestibuli and the scala tympani. Consequently, the conformation of the internal acoustic meatus cannot be determined. A rather broad channel for the facial nerve leads to the orifice of the aquaeductus Fallopii at the anteroexternal angle of the internal acoustic meatus. The flattened foramen singulare is situated behind the low ridge which separates the spiral tract from the orifice of the aquaeductus Fallopii.

The tractus spiralis foraminosus forms two circular depressions, the hinder one being much deeper than the anterior one. The cerebral orifice of the aquaeductus cochleae is also broken off, but obviously was quite small, judging from the diameter of the aqueduct. Outside of the internal acoustic meatus and near its posteroexternal angle is the slitlike orifice of the aquaeductus vestibuli that opens into a rather deep triangular fossa.

External to the internal acoustic meatus, the cerebral face of the outer denser portion of the periotic is noticeably flattened and forms an obtuse angle with the shallowly concave external face. On the posterior face of this denser portion and above the hinder end of the stapedial fossa is a rather large depression, subtrapezoidal in outline.

The posterior process of the right periotic (USNM 20659) referred to this species is essentially complete and the structures on the cerebral face are undamaged. The articular facet (pl. 5, fig. 2) on the ventral face of the somewhat elongated and distally truncated posterior process of this right periotic is shallowly concave on the basal portion and slopes from the distal extremity to the anterior margin. A few shallow grooves traverse this facet in an oblique direction.

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The ventrointernal border of this facet projects inward and contributes the floor for the facial canal. A rather distinctly margined subpyriform excavation, which is located on the internal side and at the base of the ventral surface of the anterior process, constitutes the fossa for the reception of the head of the malleus. In contrast, the corresponding fossa on the left periotic associated with the skull is shallower.

The fossa incudis occupies the same location as on the left periotic, but is narrower and more elongated and is continued downward on the anteroexternal angle of the posterior process.

On the cerebral face of this right periotic (pl. 5, fig. 5) the internal acoustic meatus is somewhat compressed from side to side and elongated, and terminates in a narrow slitlike channel for the passage of the facial nerve. This channel leads to the entrance of the aquaeductus Fallopii and is slightly constricted medially by a narrow lip projecting from the pars cochlearis. The small orifice for the foramen singulare is situated posterior to the low osseous ridge between the spiral tract and the entrance to the aquaeductus Fallopii.

The tractus spiralis foraminosus is well defined with a minute foramen centrale at the anterior end. Outside and posteroexternally to the rim of the internal acoustic meatus is the small orifice of the aquaeductus vestibuli that opens into a deep ovoidal fossa. There is an interval of 4.2 mm. between it and the cerebral orifice of the aquaeductus cochleae. The cerebral orifice of the aqueduct of the cochlea is slightly larger than that for the vestibule and opens into the groove on the posterior face of the pars cochlearis at least 3 mm. below the rim of the internal acoustic meatus. On the posterior face of the periotic and above the posterior margin of the stapedial fossa there is a shallow circular depression approximately 5 mm. in diameter.

MEASUREMENTS OF THE PERIOTICS (IN MILLIMETERS)

	L. calvertensis (USNM 16314) Left periotic	*L. pappus* (USNM 15985) Left periotic	*L. pappus* (USNM 20659) Right periotic
Breadth of periotic at level of fenestra ovalis (as measured from external face above groove to internal face of pars cochlearis)	20. 1	19. 5	18. 5
Greatest length of periotic (tip of anterior process to tip of posterior process)	32. 2	31. 4+	31. 5

Greatest dorsoventral depth of periotic (as measured from most inflated portion of tympanic face of pars cochlearis and groove to most projecting point on cerebral face)	15. 4	13. 1	12. 0
Distance between fenestra rotunda and tip of anterior process	21. 0	20. 0	17. 3
Distance between fenestra rotunda and anteroexternal angle of posterior process	15. 2	13. 5	15. 6
Distance between epitympanic orifice of aquaeductus Fallopii and tip of anterior process	16. 6	16. 0	14. 0

TYMPANIC BULLA

The right tympanic bulla (pl. 6, figs. 4, 5) lacks the posterior process and most of the thin outer lip, including the uncinate process. The sigmoid process is preserved, but the intervening portion of the outer lip is missing and consequently its position cannot be determined with accuracy.

The ventral and external surfaces of this tympanic bulla are somewhat roughened but are not as nodular as the ventral face of the bulla of *Inia geoffrensis*. The configuration of the involucrum, however, is quite unlike that of *Inia geoffrensis*, and is somewhat similar to that of *Lipotes vexillifer*.

The anterior end of the tympanic bulla is flattened, forming a narrow lip which projects forward, and the thin outer lip is sufficiently complete to indicate the size and direction of the anterior outlet of the eustachian canal. The involuted thicker portion of the tympanic bulla is depressed below the level of the arching thin outer lip and is abruptly attentuated about 10 mm. behind the anterior outlet of the Eustachian canal. The surface of the involucrum is slightly roughened, convex from side to side, and depressed opposite the sigmoid process.

The ventral surface of the tympanic bulla is somewhat flattened on the anterior 15 mm. of its length. A large deep groove behind this flattened area divides the ventral surface longitudinally.

Measurements of Right Tympanic Bulla of USNM 15985 (in millimeters)

Greatest length of bulla	38. 0
Greatest depth of bulla on internal side (ventral face to dorsal face of involucrum)	14. 0
Greatest width of involucrum	11. 1

TEETH

During the removal of the matrix, 75 detached teeth were found near the skull and mandibles. The detached teeth range from 19.8 to

34.6 mm. in total length and the roots of the same teeth from 16 to 26 mm. With the exception of the pair of teeth at the extremity and seven additional teeth on each side, the teeth were dislodged from the alveolae on both sides of the rostrum. Fortunately, differences in the size, depth, and conformation of the empty alveolae made it possible to place with reasonable certainty the teeth found in the adjacent matrix in the corresponding alveolae. Nevertheless, no teeth were found that matched five alveolae on each side of the rostrum, although it is quite likely that two additional teeth for which the crowns alone were found were originally lodged in the rostrum.

In the mandibles, however, all of the teeth except one in the left mandible were dislodged from the alveolae. When the teeth were fitted to the corresponding mandibular alveolae, no teeth were found for two alveolae in the right mandible and one in the left mandible.

The dental formula was originally:

$$\frac{\text{R.27}-\text{L.26}}{\text{R.26}-\text{L.26}}$$

Although the crowns of most of the teeth in both the upper and lower jaws were worn to varying degrees, some at least are sufficiently complete to show that the crowns curved inward toward the apex. The inner surface of the crown above the base was somewhat rugose, although the black enamel elsewhere on the crown is essentially smooth. None of these teeth exhibit any trace of accessory cusps or tubercles. The basal margin of the enamel crown is irregularly curved, but no cingulum is developed. The root on most of the teeth appears to have been slightly constricted immediately below the enamel crown. The extremities of the roots of most of the teeth are bent backward. All of the teeth in the rostrum with the exception of four or five of the posterior ones have the roots noticeably expanded below the crown and tapered toward the extremity.

On this fossil skull the anterior teeth and their alveolae are the largest in each tooth row; the teeth and their alveolae progressively diminish in size toward the posterior end of the tooth row. The teeth and alveolae of *Inia geoffrensis*, however, increase in size from the anterior to near the posterior end of the tooth row and the anterior teeth have rather small recurved crowns with rugose or finely striated enamel. The seven hindmost teeth of *Inia* have the crowns and the roots widened transversely, the enamel crown of each consisting of an outer low blunt pointed cusp and a flattened rugose internal shelf that occupies about half of the transverse width of the crown.

The 10 anterior teeth on each side of the rostrum are separated by interspaces of varying widths, and the remainder of the teeth are

rather closely approximated. The interspace on the right side between the fifth and sixth alveolae, counting backward from the anteriormost alveola, is 8 mm., between the sixth and the seventh alveolae it is 4 mm. On the right side of the rostrum the alveolae of the 20 posterior teeth counting forward from the hindmost one are separated by rather thin septa (1 mm. or less).

The anteriormost tooth on each side of the rostrum has the apex of the crown worn off obliquely and the posterior surface of the crown deeply grooved from occlusion with the corresponding tooth in the mandible. Each of these large teeth is placed obliquely in the alveola at the extremity of the premaxilla, and projects forward and downward. These anteriormost teeth diverge from one another toward their apices. The worn enamel crown of the anteriormost tooth on the right side measures 14 mm. in length and 10 mm. in diameter at the base. The ratio of the length of the enamel crown to the whole tooth varies considerably in the upper tooth row, being equivalent to nearly half the total length on the largest anterior teeth and about one-third the total length on the larger teeth near the posterior end of the tooth row. With the exception of five teeth at the anterior end of the tooth row and six at the posterior end, the enamel crowns of most of the remaining teeth are worn down to the roots. The tooth at the posterior end of the right upper tooth row is the smallest, measuring 19.7 mm. in length; the maximum diameter of the root is 5.8 mm. The longest anterior teeth (the fourth on left side and the fifth on right side) have a length of 31 mm., and a root with a maximum diameter of 11.8 mm. The three anterior teeth on each side are lodged in the premaxillae.

The anterior mandibular teeth average smaller than the corresponding ones in the rostrum. Behind the three anterior teeth on the right side, the crowns of at least nine of the succeeding teeth were worn down to the roots, although only four on the opposite side were worn to the same extent. The anteriormost pair of teeth were worn obliquely from occlusion with the corresponding upper teeth. On the left side the second, third, fourth, and fifth teeth counting backward from the first are sufficiently complete to show that the enamel crowns curved inward and backward toward their apices. The enamel crown of the second tooth measures 11.5 mm. in length and 7.6 mm. in breadth at the base; the total length of the tooth is 31.3 mm. Twelve teeth were located in the symphyseal portions of the right and left mandibles. The posterior tooth in the left mandible is the smallest in this tooth row, measuring 26 mm. in length; the crown length is 7.5 mm., the greatest breadth of crown at base is 6.2 mm; and the greatest breadth of root is 8 mm.

CERVICAL VERTEBRAE

Of the seven vertebrae normally comprising the cervical series of a cetacean, only four (pl. 7) were found associated with the skull and mandibles. No evidence of ankylosis exists on any of these cervicals.

The axis, the third to seventh cervicals, and the first and second dorsal vertebrae of *Lophocetus calvertensis* are for the most part concealed by matrix. The ventral surfaces of these centra are somewhat eroded and only small remnants of the lower transverse processes are preserved. All of these vertebrae are sufficiently complete, however, to assist with the allocation of the cervicals of *L. pappus*. The dorsal portions of the neural arches of the fourth to seventh cervicals of *L. calvertensis* are fairly complete and are relatively narrower anteroposteriorly than those of the Calvert Miocene porpoise. The anteroposterior diameters of the centra of the fifth, sixth, and seventh cervicals of this Calvert porpoise are likewise greater than those of corresponding cervicals of the St. Marys porpoise. The fifth and sixth cervicals of *L. calvertensis* agree with those of *L. pappus* in having lower transverse processes, and the seventh seems to possess on each side a single upper laterally projecting transverse process.

Atlas: In general form the atlas (pl. 7, fig. 1) differs from that of *Eurhinodelphis cocheteuxi* (Abel, 1931, pl. 19) in having vestigial upper transverse processes, a broader and longer hyapophysial process, and a wider neural canal. The reduction of the upper transverse processes, the enlargement of the lower transverse processes, the greater anteroposterior diameter of the roof of the neural arch (completely enclosing the vertebrarterial canals), and the widened hyapophysial process distinguish this atlas from that of *Inia geoffrensis*. The atlas of *Lophocetus calvertensis* resembles that of *L. pappus* in essential details. but is slightly wider, the posterior facets for articulation with the axis are considerably larger, the large vertebrarterial canals do not pierce the roof of the neural arch and are bounded in part by the dorsointernal edges of the anterior facets for articulation with the condyles, and the roof of the neural arch is more strongly arched.

The lower transverse processes are normal in size, truncated obliquely at extremity, but only vestiges of the upper processes persist. These lower processes are short, dorsoventrally compressed, and project downward and backward. The facets for articulation with the occipital condyles are concave, broader above than below, and separated ventrally by an interval of 11 mm. The roof of the neural arch is not elevated medially, the anteroposterior diameter near the low crestlike neural spine measuring 25.5 mm., and is pierced on each side by a vertebrarterial canal. The posterior articular facets

(pl. 7, fig. 5) are subovoidal in outline, convex from side to side, slightly concave dorsoventrally, and are set off from the posterior face of the centrum by distinct margins. The hyapophysial process is rather large, flattened dorsoventrally, and noticeably rugose dorsally along lateral and hinder borders. On the dorsal surface of the hyapophysial process, and at the base of the somewhat pyriform neural canal, there is a concave heart-shaped facet for articulation with the odontoid process of the axis.

For comparison, the measurements, in millimeters, of the atlas of *Lophocetus calvertensis* are as follows: Greatest distance across atlas between outside margins of anterior articular facets, 93; across posterior facets, 96.5; distance across atlas between tips of transverse processes, 121+; and greatest transverse diameter of neural canal anteriorly, 38.

Fifth cervical: Unlike the fifth cervical of *Inia geoffrensis*, this vertebra (pl. 7, fig. 3) lacks the downwardly projecting, elongated, and rather robust lower transverse processes. It is distinguished also by the fusion of the thin upper transverse process with the thicker lower one, completely enclosing on each side the large vertebrarterial canal, and by downward projection of the short ventrally directed process that arises near the base of the lower transverse process. The centrum is rather thin (16 mm.), the dorsal portion of the slightly elevated neural arch is narrow, and the neural spine is reduced to a low crest. The prezygapophysial facets slope obliquely downward from outer to inner margins. The postzygapophysial facets are rather large, and are placed obliquely on the posterosuperior border of the pedicle of the neural arch.

Sixth cervical: The transverse processes of this cervical (pl. 7, fig. 2) are incomplete distally but otherwise are well preserved. The enlargement and elongation of the lower transverse processes at once distinguish this vertebra from that of *Inia*. The upper transverse process apparently tapered to a thin distal end and may have partially inclosed the large lateral vertebrarterial canal. The lower transverse process is directed downward and backward but exhibits an irregular conformation, although somewhat flattened dorsoventrally and expanded near extremity. The centrum is slightly thicker than that of the fifth cervical. The prezygapophysial and postzygapophysial facets slope obliquely from outer to inner margins. The neural spine is a low crest, and the dorsal portion of the neural arch is slightly elevated.

Seventh cervical: In contrast to the sixth cervical, the anteroposteriorly flattened transverse processes (pl. 7, fig. 4) are directed outward from the dorsal half of the lateral face of the centrum and

are attenuated toward extremity. A small elongated vertebrarterial canal perforates the base of the right transverse process. The enlargement of these upper transverse processes and the absence of the lower transverse processes also distinguish this cervical from the sixth cervical. In development these upper transverse processes resemble somewhat those on the seventh cervical of *Inia*, which, however, has a long slender neural spine (58 mm.) and large lateral vertebrarterial canals. The pedicles of the neural arch are wider than those of the sixth cervical. The prezygapophysial facets slope less steeply from outer to inner margins than on the sixth cervical and the postzygapophysial facets are unusually elongated (24.5 mm.). The neural spine is reduced to a low crest.

MEASUREMENTS OF CERVICAL VERTEBRAE (IN MILLIMETERS)

	Atlas	C.5	C.6	C.7
Greatest vertical diameter of articular surface for condyle (right)	49. 0			
Greatest transverse diameter of articular surface for condyle (right)	32. 5			
Least anteroposterior diameter of dorsal face of neural arch	25. 8	11. 5	9. 5	12. 5
Least anteroposterior diameter of pedicle of neural arch		12. 0	14. 8	20. 5
Greatest height (vertically) of vertebra (tip of neural spine to ventral face of centrum)	84. 0	63. 5	63. 5	62. 5
Anteroposterior diameter of centrum		16. 0	17. 5	18. 0
Distance across vertebra between tips of transverse processes (parapophyses)	113. 5	94. 5	84.+	111. 5
Distance across vertebra between tips of upper transverse processes (diapophyses)			71. 0	
Distance between tip of prezygapophysis and tip of postzygapophysis		27. 7	28. 3	34. 8
Transverse diameter of neural (spinal) canal anteriorly	35. 0	26. 0	29. 0	31. 0
Maximum height of neural (spinal) canal anteriorly	37. 5	17. 5	17. 5	19. 0
Greatest distance across vertebra between outside margins of anterior articular facets	88. 0			
Greatest distance across vetebra between outside margins of posterior articular facets	82. 0			

DORSAL VERTEBRAE

With the exception of the neural spines and the extremities of the prezygapophyses, all four dorsal vertebrae (USNM 15985) associated with the skull and mandibles are otherwise essentially complete.

Another vertebra (USNM 20659), which was associated with a section of the rostrum, represents the second in the dorsal series. The position of these vertebrae in the dorsal series here adopted is based on the structural features of the dorsal vertebrae of *Inia geoffrensis* as well as on the articular relations of the ribs associated with this fossil. All of these vertebrae have the epiphyses firmly ankylosed to the centrum, indicating that the porpoise was fully mature.

These vertebrae may be distinguished from the corresponding vertebrae of *Inia geoffrensis* by the wider interval separating opposite prezygapophysial facets, the larger neural canal, and the location of the articular facet for the capitulum of the corresponding rib on the centrum at the upper posteroexternal angle. They differ also from the corresponding vertebrae of *Eurhinodelphis* in that the pedicles of the neural arches and the prezygapophyses are more noticeably robust, the neural canals are narrower, and the anterior surfaces of the centra are narrower. The centra increase in length from the second to the tenth in the series. The width of the interval separating the prezygapophysial facets decreases markedly from the second to the tenth dorsal. These prezygapophysial facets are rather large and slope steeply from outer to inner margins. On four of these dorsals the diapophyses are relatively short, and the facet for articulation with the tuberculum of the corresponding rib, with the exception of the fourth dorsal, is situated behind the level of the anterior surface of the centrum. The facets for the tuberculum of the corresponding ribs are noticeably elongated dorsoventrally on the second and fourth dorsals, but progressively widen anteroposteriorly to the tenth dorsal. The postzygapophysial facets do not differ markedly from one another on the fourth, sixth, and eighth dorsals. On each side of the centrum of the fourth and sixth dorsals at the upper posteroexternal angle there is a large facet for the accommodation of the capitulum of the following rib. This facet, however, is not present on the eighth dorsal. On the corresponding vertebrae of *Inia*, however, these facets are located on the upper anteroexternal angle of the centrum.

Second dorsal: When this vertebra (USNM 20659) was found the neural spine, the left half of the neural arch, and a portion of the left side of the centrum had been broken off while exposed on the face of the cliff. The centrum (pl. 11, fig. 3) is approximately the same size as that of the second dorsal of *Lophocetus calvertensis*. This second dorsal, however, differs from the corresponding dorsal of *Inia* in having a wider neural canal, slightly longer diapophyses with the dorsoventrally elongated facet for the tuberculum located obliquely on the posterior half of the extremity of the latter, and widely separated prezygapophysial facets, the distance between their outer margins

being estimated as 70 mm. The right pedicle of the neural arch is robust and the roof of the neural arch was apparently rather narrow anteroposteriorly, inasmuch as the distance from the anterior margin of the neural arch to the posterior margin of the postzygapophysial facet is 24.5 mm. The prezygapophysial facets are distinctly impressed on the dorsal surface of the diapophyses and slope from the outer to the inner margin. The postzygapophysial facets are elongated (17.5 mm. in length) and slope obliquely downward and inward. The large facet for the capitulum of the third rib is located obliquely on the centrum at the upper posteroexternal angle.

Other measurements, in millimeters, for the second dorsal are as follows: Greatest anteroposterior diameter of centrum, 26.5; greatest transverse diameter of posterior face of centrum, 46+; greatest vertical diameter of anterior face of centrum, 31.5.

Fourth dorsal: This vertebra (pl. 8, figs. 2, 6) differs from the corresponding dorsal of *Inia* in having a more nearly circular instead of subpyriform neural canal, a pronounced widening of the posterior surface as contrasted with the anterior surface of the centrum, steeply sloping prezygapophysial facets, the long axis of the facet for the tuberculum on the diapophysis nearly vertical, and the large facet for capitulum of fifth rib located obliquely on the centrum at the upper posteroexternal angle. From the corresponding vertebra of *Eurhinodelphis* this dorsal is distinguished by having shorter diapophyses, a more nearly circular neural canal, and the posterior surface of the centrum noticeably wider than the anterior face. Although the neural spine is broken off at the base, the position and curvature of the anterior edge suggest that it was rather broad anteroposteriorly. The backwardly projecting dorsal portion of the neural arch is elongated anteroposteriorly (36 mm. medially) and rather wide (42 mm.). The neural arch is robust, with a short diapophysis on each side which bears a pyriform anticular facet for the tuberculum of the fourth rib. The prezygapophysial facets are somewhat concave anteroposteriorly and slope steeply from outer to inner margins. The postzygapophysial facets are elongated and slope obliquely downward and inward.

Sixth dorsal: Compared with the fourth dorsal, the backwardly projecting dorsal portion of the neural arch is considerably narrower and longer anteroposteriorly (40 mm.), the centrum is longer, and the prezygapophyses are more elongated and narrower. The short diapophyses (pl. 8, figs. 1, 5) do not differ markedly either in position or in size from those on the fourth dorsal, and the facets for the tubercula of the sixth ribs are noticeably constricted ventrally. The concave prezygapophysial facets are shorter and narrower dorsoventrally than on the fourth dorsal, although the conformation and size of the

postzygapophysial facets are quite similar to those on the latter. The facet for the capitulum of the seventh rib is large and situated on the centrum at the upper posteroexternal angle. The anterior surface of the centrum is narrower than the posterior surface.

Eighth dorsal: The prezygapophyses (pl. 9, figs. 3, 4) are separated by a shorter interval, the neural canal is noticeably smaller, and the backwardly projecting dorsal portion of the neural arch is very narrow and more noticeably attenuated than on the sixth dorsal. The anterior and posterior surfaces of the centrum are approximately the same width.

The anteroposterior diameter of the basal portion of the neural spine exceeds that of the corresponding dorsal of *Eurhinodelphis*, but is approximately equal to that of *Inia*. The short diapophyses differ very slightly in position from those of the sixth dorsal, although the facets for articulation with the tubercula of the eighth ribs are almost triangular in outline. The concave prezygapophysial facets are small, measuring about 16 mm. anteroposteriorly, and slope very abruptly from outer to inner margins. The somewhat curved and slender prezygapophyses project about 17 mm. beyond the anterior margins of the ventrally situated articular facets. The postzygapophysial facets are similar in outline to those of the sixth dorsal, but are shorter. The centrum lacks any indication of a facet for the capitulum of the ninth rib. On the centrum of the corresponding dorsal of *Inia*, however, the large facet for the capitulum of the eighth rib is located on the upper anteroexternal angle of the centrum and is continuous with the facet for the tuberculum.

Tenth dorsal: The eighth and ninth dorsal vertebrae of *Inia* have the single large facet for the combined tuberculum and capitulum of the corresponding rib located for the most part on the lateral surface of the pedicle of the neural arch. On the tenth dorsal of *Inia*, however, this facet is located largely below the level of the dorsal surface of the centrum. The transverse processes of these vertebrae of *Inia* are very short. This fossil vertebra (pl. 9, figs. 5, 6) thus differs from the tenth dorsal of *Inia* in having the single large concave articular facet for the combined tuberculum and capitulum of the corresponding rib located laterally on the rather robust transverse process, which projects outward from the pedicle of the neural arch at a lower level than on the eighth dorsal. The distance from the inner surface of the pedicle of the neural arch to extremity of the transverse process is 27 mm. The anteroposterior diameter of the neural spine at the base is greater, the neural canal is narrower, and the prezygapophysial facets are much more closely approximated than on the eighth dorsal. The concave prezygapophysial facets slope abruptly

from outer to inner margins. The postzygapophysial facets are much smaller and less sharply outlined than those of the eighth dorsal. A slight increase in the length of the centrum also distinguishes this vertebra from that of the eighth dorsal; the transverse width of the posterior surface (40.5 mm.) of the centrum is only slightly greater than the corresponding measurement of the anterior surface (39.5 mm.)

MEASUREMENTS OF DORSAL VERTEBRAE (IN MILLIMETERS)

	D.4	D.6	D.8	D.10
Greatest vertical height of vertebra, ventral face of centrum to tip of neural spine	78.+	80.+	102. 5	119.+
Vertical height of neural spine, dorsal surface of neural canal to tip of neural spine			53.+	70. 5
Greatest anteroposterior diameter of centrum	38. 5	40. 5	42. 0	47. 8
Greatest transverse diameter of anterior face of centrum	37. 5	38. 5	40. 0	39. 5
Greatest vertical diameter of anterior face of centrum	26. 5	32. 6	34. 2	35. 0
Greatest vertical diameter of neural (spinal) canal anteriorly	29. 0	28. 0	25. 0	24. 0
Greatest transverse diameter of neural (spinal) canal anteriorly	32. 0	30. 5	28. 0	25. 5
Least anteroposterior diameter of pedicle of neural arch	16. 5	16. 0	17. 7	23. 8
Distance across vertebra between outer ends of diapophyses	84. 8	80. 7	74. 5	81. 7
Greatest distance between outer margins of prezygapophysial facets	49. 5	50.±	35. 2	23.±
Greatest distance between outer margins of postzygapophysial facets	41. 5	30. 0	17. 5	
Distance between tip of metapophysis and posteroventral angle of neural spine	63. 5	67. 0	69. 5	67.+

CAUDAL VERTEBRAE

The terminal caudal (USNM 20659), probably the third or fourth (pl. 11, fig. 2) from the distal end of the vertebral series, resembles the corresponding vertebra of *Inia geoffrensis*. The dimensions in millimeters are as follows: Greatest width, 34; vertical diameter of anterior surface, 18; and anteroposterior diameter, 15. Short, blunt upper and lower processes are formed on each side by the medial side to side constriction of the centrum. The anterior surface of the

centrum is shallowly concave, and the posterior surface convex. The centrum is pierced dorsoventrally by a pair of canals, the dorsal orifices of which are 9 mm. apart.

RIBS

Although all of the ribs (pl. 10) associated with these skeletal remains are more or less incomplete, there is evidence that this fossil porpoise possessed at least 10 pairs of ribs and possibly 13, of which the first pair are short and robust. When these ribs are arranged in what appears to be their normal position, the abrupt downward bending of the shaft behind the neck is seen to diminish from the anterior to the posterior end of the series.

For the first rib (pl. 10, fig. 1) on the left side only a section of the curved portion of the shaft behind the tuberculum was found. The neck is flattened, and relatively deep behind the tuberculum of which only the hinder border of this articular surface is preserved. The downward bending of the shaft of the rib behind the tuberculum apparently was not as abrupt as on the corresponding rib of *Inia*.

The right and left second ribs (pl. 10, figs. 2, 7) both lack their distal extremities, but are otherwise somewhat similar to the ribs of *Inia*. The necks of these ribs are short, the capitular portion being slightly bent upward. The tuberculum is elongated, with greatest width posteriorly (11.5 mm.) and attenuated anteriorly. Between the tuberculum and the angle the posterosuperior margin overhangs interruptedly the posterior surface of the shaft. The downward bending of the flattened shaft is more pronounced than on the succeeding ribs.

Only the proximal end of the third rib (pl. 10, fig. 10) on the right side was found. The neck is narrower and slightly longer than that of the second rib. The convex capitulum is subovoidal in outline. The tuberculum is elongated, subpyriform in outline, and concave from end to end.

The necks of the right and left fourth ribs (pl. 10, figs. 3, 8) are slender, less flattened, and more elongated than that of the third rib. The capitulum is broken off on the left rib and is incomplete ventrally on the right rib, but was obviously smaller than that of the third rib. The slightly convex tuberculum is extended anteriorly on the neck. Between the tuberculum and the angle the shaft of this rib is anteroposteriorly flattened, but becomes more nearly ovoidal in cross section toward the broken distal end. The angle overhangs the posterior face of the shaft.

The fifth rib (pl. 10, fig. 4) on the left side is characterized by a slender neck, an expanded capitulum, and an elongated tuberculum

which is concave from end to end, and wider posteriorly than anteriorly. The shaft of the rib is flattened anteroposteriorly between the tuberculum and the angle, almost ovoidal in cross section near the middle of its length, and noticeably flattened near the extremity. The length of this rib in a straight line is 306 mm.

The neck of the sixth rib (pl. 10, fig. 5) resembles that of the fifth rib, and the shaft is similarly flattened between the tuberculum and the angle. The capitulum is rounded. The tuberculum unfortunately was destroyed during excavation of this specimen.

A single-headed rib (pl. 10, fig. 9) lacking the distal end may have articulated with the tenth dorsal. The proximal articular surface of this rib is somewhat convex, the shaft is thickened between this facet and the angle, and below the angle it is distinctly flattened on the outer surface for a distance of about 60 mm.

Another single-headed rib (pl. 10, fig. 6) from the posterior end of the series on the right side has a large proximal articular surface, a sharp crest approximately 30 mm. in length on the anterosuperior margin behind the articular head, and an ill-defined angle below which the shaft becomes progressively flattened and develops a ridge on the anterior and posterior margins.

SCAPULA

It will be noted that the lower portion of this left scapula (USNM 20659) is quite unlike the scapula of *Inia geoffrensis*. The neck of this scapula (pl. 11, fig. 4) is short and rather broad and the glenoid cavity for the head of the humerus is rather shallow. The lower or axillary margin is directed backward and slightly upward from the short neck. The direction and length of this margin suggests that the upper portion of the scapula was rather broad. Since the external surface of this bone is slightly depressed posterior to the assumed position of the spine, a shallow postscapular fossa is indicated. The basal portion of the acromion process is rather broad. The laterally flattened coracoid process lacks the distal end and is directed inward and apparently slightly upward from the neck of the scapula.

II. PELODELPHIS GRACILIS, NEW GENUS, NEW SPECIES

Our present knowledge of the cetacean fauna of the Calvert formation of Maryland indicates that in addition to the more frequently occurring long-beaked porpoises of the genera *Eurhinodelphis*, *Schizodelphis*, and *Zarhachis*, at least one other porpoise with a lengthened rostrum was present during that period in the Chesapeake area. It is now certain that remains of a number of genera and several families of Cetacea were present in the marine Miocene Calvert formation.

The possibility exists, however, that one of the names given by either Leidy or Cope to vertebrae or teeth from the Miocene formations of Maryland or Virginia may be applicable to this previously unrecognized long-beaked porpoise. Until a skull is found with at least some associated vertebrae and teeth that are satisfactory for comparison with these type vertebrae and teeth, the identity of some of the forms described by Leidy and Cope will remain questionable.

The porpoise hereinafter described was characterized by larger teeth than any of the above mentioned long-beaked genera, although the total length of the skull was unquestionably shorter. Comparative measurements suggest that the total length of the skull did not exceed 630 mm. Not one of the European Miocene porpoises heretofore described agrees with the mandible of this Calvert porpoise in essential characters.

Three of the European forms, however, deserve some comment. As regards the type mandible of *Palaeoziphius scaldensis* (Abel, 1905, p. 91, fig. 15) which was found in the excavations at Antwerp in deposits of Bolderian age, the alveolae, in addition to being slightly larger (12 were located on the symphysis in an interval of 168 mm. as compared to 16 on the mandible hereinafter described), appear also to have been separated by thicker septa. Although the width (44 mm.) of the posterior end of the symphysis of *Palaeoziphius scaldensis* is less than that (52.5 mm.) of this Calvert specimen, the variation in the transverse diameter of both specimens 168 mm. anterior to the posterior end of the symphysis is not more than 2 mm. The opposite free hinder portions of the mandible of the Belgian *Palaeoziphius* form an acute angle at the level where they ankylose as the symphysis, whereas in the Calvert specimen the rami form a rather wide blunt angle. In addition the anterior end of the symphysis of the Belgian specimen is more noticeably bent upward and the furrow or groove on the lateral surface of each ramus according to Abel is deep and anteriorly bifurcated. The symphysis of this type mandible is incomplete anteriorly.

The ankylosed mandibles found in a marl pit of Helvetian age at Montfort near Dax, Landes Department, France, which constitute the type of *Champsodelphis lophogenius* (Valenciennes, 1862; Type, No. 11731, Lab. Paléont., Mus. Nat. Hist. Nat., Paris) are characterized in part by a slightly narrower width (43.2 mm.) at the posterior end of the symphysis, although the vertical diameter (42.6 mm.) of the left mandible at the hindmost alveola is identical. However, the angle (Van Beneden and Gervais, 1874, pl. 57, fig. 10a) formed by the opposite mandibles behind the point where they ankylose to constitute the symphysis is acute, in contrast to the more rounded angle

exhibited by Calvert mandibles. Although the alveolae were more widely spaced, the teeth were somewhat smaller in size since 10 alveolae in the left mandible occupy an interval of 114 mm.

The mandible from the shell marl (Falun) of Helvetian age at Salles, Gironde Department, France, referred to *Champsodelphis dationum* by Gervais (1859, pp. 305–306), is slightly smaller than that of this Calvert specimen, since the height of the left mandible at the posterior end of the symphysis is stated to be 28 mm. and at posterior alveola 35 mm. The illustration for this mandible (Gervais, 1859, pl. 83, fig. 1) shows that the intervals between the alveolae were wider and that the teeth were smaller—12 alveolae were located in an interval of 111 mm.

Pelodelphis, new genus

Diagnosis: Mandibles slender with elongated symphysis equivalent to less than one-half the length of each ramus when complete; symphysis ankylosed, tapering toward anterior extremity, approximately U-shaped in cross section about half way of its length, and with anterior half of its length bent upward; opposite free hinder portions of mandibles form a blunt angle at level where they ankylose as symphysis; probably 36 teeth in each mandible; 12 alveolae located on each mandible posterior to hinder end of symphysis; 21 alveolae located on preserved portion of left mandible anterior to posterior end of symphysis; roots of teeth on symphysis implanted obliquely in alveolae, which slope more backward than inward; anteroposterior diameter of each of two alveolae at hinder end of symphysis in right mandible, 9 mm.; transverse diameter of the same alveolae, 9 mm.; diameters of anterior alveolae approximately 1 mm. smaller; opposite alveolae at hinder end of symphysis separated by an interval of 22.5 mm.; corresponding interval between 16th alveolae (counting forward from hindmost at posterior end of symphysis) is 5.5 mm.

Pelodelphis gracilis, new species

Plates 12–16

Type specimen (USNM 13471): Ankylosed mandibles lacking distal ends of both rami; hinder portion of right mandible incomplete. Collectors, Remington Kellogg, C. Lewis Gazin, and Raymond M. Gilmore, Aug. 11, 1933.

Horizon and locality: In sandy clay of Zone 14 (about 18 inches above contact with Zone 13), approximately 583 yards north of old pier at end of Governor's Run Road (see U. S. Geol. Surv. Prince Frederick Quad.), Calvert County, Md. Calvert formation, upper Miocene.

MANDIBLES

The anterior extremities of both mandibular rami (pl. 12, fig. 1) are broken off; the condyle and a portion of the ramus below and behind the coronoid process is missing on the right mandible; the left mandible is essentially complete except for the lower border in front of the condyle. In the present condition, the symphyseal portion (229 mm.) of the left mandible is shorter than the hinder free portion (307 mm.). The mandibles are firmly ankylosed throughout the length of the symphysis. A thin dorsal groove along the midline on the anterior half of the symphysis marks the ankylosis of the opposite mandibles. On the posterior half of the symphysis this groove is more or less obliterated. On the ventral face the line of fusion is indicated by a continuous narrow groove that extends medially the full length of the symphysis.

The symphyseal portion of the combined lower jaws tapers toward the anterior extremity, the transverse diameter diminishing from 52.5 mm. at the level of the posterior end to 25.4 mm. at the level of the 29th alveola, counting forward from the hindmost alveola in the ramus, although the dorsoventral reduction is less marked. From a lateral view (pl. 13, fig. 2) the ventral profile of the distal 130 mm. of the symphysis slopes slightly upward toward the missing anterior extremity. Between the tooth rows the dorsal surface of the symphysis is relatively smooth. No pits for the reception of the apices of the teeth in the upper jaws are present. The external face of the symphyseal portion of the right mandible is slightly convex, but slopes obliquely from the alveolar margin to the midline of the ventral surface. A cross section taken about half way of the length of the ankylosed symphyseal portions of the mandibles resembles a U, but is more nearly V shaped near the extremity.

The distance (117 mm.) from the posterior end of the symphysis to the posterior margin of the hindmost alveola on the right mandible is greater than the interval (77 mm.) between the opposite tooth rows at the level of this tooth. The angle formed by the diverging opposite rami behind the symphysis is approximately 30 degrees.

More than 33 alveolae were present on the left mandible when complete. If the extremity of the symphysis had been preserved the number of alveolae would be increased, probably at least to 36. This extinct porpoise had originally more than 21 teeth on each side of the ankylosed symphysis, as contrasted to 12 in the case of *Lophocetus pappus*, new species. The teeth on the anterior half of the symphysis were implanted opposite one another, the alveolae being separated by equivalent intervals from preceding and succeeding

alveolae. The maximum interval between alveolae is about 2 mm. The septa between the alveolae are in most instances complete. On the right mandible in front of the 29th tooth, counting forward from the hindmost, the alveolae were obliterated by exostosis. Except for a slight inward slope, the roots of the teeth were implanted nearly vertically in the alveolae behind the symphysis. Along the symphysis, however, the roots were implanted obliquely in the alveolae, sloping more backward than inward. The distance between opposite alveolae immediately in front of the posterior end of the symphysis is 22.5 mm., and 5.5 mm. at the level of the 29th alveolae, counting forward from the hindmost on the left mandible. In the right mandible, 12 alveolae (in an interval of 117 mm.) were located behind the level of the posterior end of the symphysis, and in the left mandible 11 alveolae (in an interval of 103.5 mm.) were so situated. The individual alveolae, which are essentially complete in preservation, vary in anteroposterior diameter from 6 to 9 mm., and in transverse diameter from 7 to 8.5 mm.

On the outer surface of the right mandible there are at least three nutrient foramina, and, from these grooves of varying lengths, extend forward. These nutrient foramina are located below the 8th, 10th, and 17th alveolae, counting forward from the hindmost, as well as other smaller foramina located anterior to these, but partially obscured by fractures. Nutrient foramina are located on the outer surface of the left mandible (pl. 12, fig. 2) below the 5th, 10th, 14th, and 20th alveolae. Commencing below the 20th alveola, there are in addition however, three narrow grooves, one above the other, that extend forward for at least 70 mm., but at a lower level on the outer face.

The dorsal edge of each mandible ascends gradually to the coronoid process, which has a thickened dorsal border. Although each coronoid process is bent inward, this condition may have resulted in part from crushing. The opposite coronoid processes are now separated by an interval of 102 mm. The distance from the apex of the coronoid process (163 mm.) to the hindmost alveola on the left mandible is equivalent to about 31 percent of the total length of the mandible as preserved.

Behind the hindmost alveola and on the inner face of each ramus there is a large orifice for the dental canal. Posterior to this point, the inner wall is reduced to a low thin strip along the ventral border of the mandible. The outer wall of the mandible in this region consists of a thin shell of bone that is now markedly convex except for the shallow concavity below and in front of the coronoid process.

The ventral margin of the left ramus is continued backward from the symphysis in a shallow curve toward the angle, the lower border being destroyed for a distance of 25 mm. anterior to the condyle.

The dorsoventral axis (37 mm.) of the condyle is directed obliquely outward and the external border of the condyle projects beyond the outer face of the ramus. The maximum transverse diameter of the condyle is 25.5 mm. In outline the condyle is almost lachrymiform with median spur on outer side, and is directed more outward than downward.

Measurements of the mandibles (in millimeters)

	Right	Left
Length of mandible, as preserved, condyle to anterior end		525.+
Length of mandible, as preserved, hinder end of coronoid process to anterior end	477.+	
Length of symphysis (as preserved)	210.+	229.+
Vertical diameter of mandible at hindmost alveola	44. 5	42. 5
Transverse diameter of mandible at posterior end of symphysis	52. 5	
Vertical diameter of mandible at level of posterior end of symphysis	29. 5	29. 5
Transverse diameter of symphysis 50 mm. anterior to hinder end	36. 0	
Transverse diameter of symphysis 100 mm. anterior to hinder end	30. 0	
Transverse diameter of symphysis 150 mm. anterior to hinder end	28. 0	
Vertical diameter of mandible through coronoid process	75.+	85. 5
12 posterior alveolae in an interval of	116. 5	112. 0
30 alveolae located in an interval of	306. 0	307. 0
Anteroposterior diameter of largest alveola	9. 0	9. 0
Transverse diameter of largest alveola	8. 5	8. 5
Distance from posterior end of symphysis to posterior margin of hindmost alveola	117. 0	113. 5
Distance from apex of coronoid process to posterior margin of hindmost alveola	151. 0	154. 0
Distance that orifice of dental canal is located behind hindmost alveola	10.±	10.±
Distance from posterior end of symphysis to posterior surface of condyle		306. 0
Height of condyle		37. 0
Transverse diameter of condyle		25. 5
Distance between alveolae of opposite tooth rows at posterior end of symphysis	27. 5	
Least distance between alveolae in tooth rows	2. 5	2. 0

Referred Specimen I

USNM 10715: Right and left mandibles, essentially complete to posterior end of symphysis. Collector, William Palmer, January 1914.

HORIZON AND LOCALITY: In sandy clay of Zone 5 above oyster shell layer, 4 feet above beach level, South Chesapeake Beach, Calvert County, Md. Calvert formation, upper Miocene.

MANDIBLES

Although the dimensions of the preserved portions of these mandibles are slightly smaller than those of USNM 13471, their conformation as well as the size of the alveolae resemble rather closely the mandibles of the latter. These mandibles obviously belonged to an immature individual since the symphysis has not as yet ankylosed and the condyles are narrower. Approximately 43 mm. of the symphyseal region of the left mandible is preserved.

Two teeth were preserved *in situ* in the left mandible and one in the right mandible (pl. 13). In the left mandible, 11 alveolae (in an interval of 110 mm.) were located behind the level of the posterior end of the symphysis, and in the right mandible 12 alveolae (in an interval of 120 mm.) were so situated. The largest alveolae at the rim vary in anteroposterior diameter from 7 to 8 mm. and in transverse diameter from 6 to 8 mm. The roots of the teeth were implanted nearly vertically in the alveolae. The maximum interval between the alveolae is approximately 3.0 mm., but for most of them it is not more than 2 mm.

The distance from the posterior end of the symphysis to the hindmost alveola (110 mm.) on the left ramus is slightly less than the corresponding interval on USNM 13471, and the distance from the posterior end of the symphysis to the posterior face of the condyle (283 mm.) is also less than that of USNM 13471 (306 mm.).

On the outer surface of the right mandible (pl. 14, fig. 1) nutrient foramina, from which grooves of varying lengths extend forward, were located below the 6th, 8th, 12th, and 13th alveolae (counting forward from the hindmost). Nutrient foramina on the outer surface of the left mandible (pl. 14, fig. 2) are located below the 6th, 9th, and 12th alveolae.

The slope of the dorsal margin of each ramus from the coronoid process to the hindmost alveola corresponds closely with that of USNM 13471, although the dorsal border of this process is less noticeably thickened. The distance from the apex of the coronoid process of the left mandible to the hindmost alveola is 139 mm.

The large orifice for the dental canal on the inner surface of the mandible was located at least 35 mm. behind the level of the hindmost alveola. The ventral borders of both mandibles are incomplete in the region of the angle. Both condyles are unusually narrow, the transverse diameter being 16 mm., and the dorsoventral axis (33 mm.) of each condyle is directed obliquely outward.

MEASUREMENTS OF MANDIBLES (IN MILLIMETERS)

	Right	Left
Length of mandible (as preserved) from condyle to anterior end	318.+	321.+
Length of symphysis (as preserved)	39.+	43.+
Vertical diameter of mandible at hindmost alveola	38. 5	38. 5
Transverse diameter of mandibles at posterior end of symphysis		40.±
Vertical diameter of mandible at level of posterior end of symphysis	25. 0	25. 0
Vertical diameter of mandible through coronoid process	73.+	83. 0
11 posterior teeth located in an interval of	113. 0	110. 0
12 posterior teeth located in an interval of	131. 0	121. 0
Anteroposterior diameter of largest alveola	8. 0	8. 0
Transverse diameter of largest alveola	7. 0	7. 0
Distance from posterior end of symphysis to hindmost alveola	115. 0	110. 0
Distance from apex of coronoid process to hindmost alveola		139. 0
Distance that orifice of dental canal is located behind hindmost alveola	35.±	35.±
Distance from posterior end of symphysis to posterior surface of condyle	282. 0	283. 0
Height of condyle	33. 0	29.±
Transverse diameter of condyle		16. 0
Least distance between alveolae in tooth rows	2. 0	2. 0

TEETH

The two teeth in the left mandible (the ninth and tenth, counting forward from the hindmost) have the apical portions of the crowns curved inward. The ninth tooth in the left mandible (pl. 16, fig. 9) has the basal 2 to 3 mm. of the enamel on the circumference of the crown ornamented with low tonguelike projections extending more or less vertically from the basal border, although this sculpturing is more pronounced on the internal than on the other faces. The anterior and posterior edges of the internal face are delimited by a low carina that extends to or nearly to the apex of the crown.

On the 10th tooth the anterior vertical carina is definitely on the anterior face of the crown, while the posterior carina delimits the internal face. The shallow grooves between the tonguelike projections from the basal circumference extend farther toward the apex of the crown on the internal face (pl. 16, fig.10) than on the ninth tooth.

On both of these teeth the enamel on the apical portion of the crown is relatively smooth. The measurements of the ninth tooth in the left mandible are as follows: Height of crown, 10.5 mm.; antero-

posterior diameter of crown at base, 5.7 mm.; transverse diameter of crown at base, 5.6 mm.; maximum diameter of root, 7.0 mm.

The crown of the 10th tooth (counting forward from the hindmost) in the right mandible has been broken off except for a portion of the basal inner surface. The sculpturing this basal portion of the enamel surface agrees with the teeth in the left mandible.

Referred Specimen II

USNM 20732: Two dorsal and one caudal vertebrae, one anterior rib, eleven teeth, and left tympanic bulla. Collector, Norman H. Boss, July 1920.

HORIZON AND LOCALITY: Green marl, one mile south of Chesapeake Beach, Calvert County, Md. Calvert formation, upper Miocene.

TEETH

Eleven teeth were associated with the three vertebrae and one rib. Most of the teeth are essentially complete, although the crowns of four are worn to varying degrees. These teeth, unlike those of *Tretosphys gabbii* and *Delphinodon dividum*, have the enamel on the crown very lightly ornamented, and the anterior teeth have noticeably elongated and nearly straight roots.

To emphasize the differences existing between these teeth and those of *Tretosphys gabbii*, the most ovious characteristics of the latter may be summarized as follows: A number of the teeth possess a vertically directed denticulated carina on the outer surface of the crown, while others have the enamel on this surface ornamented with fine striae; the posterior teeth, at least, have a fairly large accessory cusp with a serrated cutting edge near the base of the posterior face; and the inner surfaces of the crowns of many of the posterior teeth are more noticeably rugose. In comparison to *Delphinodon dividum*, the teeth of this porpoise possess gibbous roots with a more pronounced curvature, and the posterior ones lack the strongly developed accessory cusps on the inner face of the crown.

On seven of the teeth the narrow basal border on the enamel of the inner face of the crown is slightly elevated and the irregular upper edge of this border appears to the eye to be indistinctly sculptured. The crown curves inward and is not markedly compressed anteroposteriorly. Two of the teeth have a pair of upwardly diverging carinae that originate on one tooth (pl. 16, figs. 1, 8) in a series of slightly elevated rugosities on the basal portion of the posterior face of the crown, and on the other tooth (pl. 16, figs. 2, 6) near the middle of the height of the posterior face of the crown. Both of these teeth

possess a small tubercle above the base of the crown on the posterior basal angle. One tooth (pl. 16, figs. 3, 7) has, in addition, a very small cusp above the basal cusp on the posterior face. With the exception of the elongated anterior teeth the outer face of the enamel crown of most of the teeth is lightly sculptured near the base. Four teeth have a faint carina on the outer face extending from the base toward the apex of the crown. On most of the teeth, however, the enamel on the crown above the lightly ornamented basal portion is relatively smooth (pl. 16, fig. 7). The ratio of the height of the enamel crown varies considerably, being equivalent to less than 18 percent of the length of the longest tooth and to less than 28 percent of the shortest tooth.

The roots of the two elongated teeth (pl. 16, fig. 5) are nearly straight, while those of the other teeth are more or less curved. The roots of the posterior teeth are expanded below the crown and taper toward the extremity. The swelling is most noticeable on the upper third of the root (pl. 16, fig. 3) of six of the teeth and on the upper half of the others (pl. 16, fig. 2). Most of the roots are compressed from side to side near the extremity. The elongated teeth were implanted presumably at the extremity of the rostrum, since similarly elongated teeth have been recorded for *Kentriodon pernix* (Kellogg, 1927, pl. 8, fig. 1).

Among the unfigured teeth there are four that exhibit deviations from those described above. Under visual examination the enamel on the crowns of these teeth appears to be rather smooth, but when magnified 4 to 10 times the ornamentation described below can be seen.

One complete tooth, 34 mm. in length, has the basal 3 mm. of the enamel on the circumference of the crown wrinkled or more precisely ornamented with low tonguelike projections extending more or less vertically from the basal margin, as well as a faint vertical carina on the posterior side of the internal face, and a similar carina on the anterior side of the external face. This ornamentation of the enamel around the basal circumference of the crown is similar to that of the teeth in the left mandible (pl. 16, figs. 9, 10).

Another essentially complete tooth, 31.5 mm. in length, although worn on the posterior face, has a similar but less well developed ornamentation on the circumference of the base of the crown, in addition to a number of fine irregular vertical carinae spaced approximately 2 to 3 mm. from one another on all sides of the preserved portion of the crown.

A somewhat longer tooth, 37 mm. in length and lacking the posterior half of the crown, has a carina on the anterior edge of the internal face and a faint oblique carina on the anterior face in addition to short

oblique wrinkles extending upward about 2 mm. above the basal margin.

A fourth tooth, 28 mm. in length and lacking the external face of the crown, possesses rugosities above the base on the anterior, internal, and posterior faces. At least four or five vertical carinae extend from these basal rugosities toward the apex of the crown.

MEASUREMENTS OF TEETH (IN MILLIMETERS)

	Posterior (pl. 16, fig. 1)	Posterior (pl. 16, fig. 2)	Posterior (pl. 16, fig. 3)	Posterior (pl. 16, fig. 4)	Anterior (pl. 16, fig. 5)
Greatest length (as preserved)	34. 2	33. 4+	32. 4+	29. 5	45. 6
Length of root	24. 4	22. 0+	21. 8+	20. 4	36. 4
Greatest diameter of root	9. 8	10. 0	9. 0	9. 4	10. 2
Height of crown	10. 4	10. 0	10. 5	8. 1	8. 0
Greatest anteroposterior diameter of crown	5. 3	5. 2	6. 8	4. 9	5. 2
Greatest transverse diameter of crown	6. 2	6. 1	7. 0	5. 0	4. 5

TYMPANIC BULLA

This left tympanic bulla is slightly larger than that of *Kentriodon pernix* (Kellogg, 1927, p. 28, pl. 1, figs. 2, 5). It lacks most of the outer lip, its processes, and the posterior apophysis. When viewed from the ventral side, the posterior portion is seen to be characterized by a deep groove, the anterior portion is depressed on the outer half, and the profile of the inner surface is more convex than that of *Kentriodon pernix*. The conformation of the involucrum is similar to that of *K. pernix* except that it is more attentuated anteriorly. The greatest length of this bulla is 35 mm., and the greatest width of the involucrum posteriorly is 13 mm.

DORSAL VERTEBRAE

The two dorsal vertebrae associated with the eleven teeth resemble *Tretosphys gabbii* in the dorsoventral elongation of the neural canal. One of them (pl. 15, fig. 1) is considered to be the fourth in the dorsal series. This vertebra differs from the anterior dorsal of *T. gabbii* in having a larger centrum, more closely approximated prezygapophysial facets, more robust diapophyses, and a slightly narrower neural canal.

The deeply concave lateral surface of the centrum (pl. 15, fig. 4) is continuous with the depression on the outer surface of the pedicle of the neural arch. As contrasted with the anterior face of the centrum, the posterior face (pl. 15, fig. 7) is noticeably wider (39.5

mm.). Dorsally the centrum is deeply depressed, and medially a small foramen is located on each side of the thin longitudinal ridge. An elongated facet for the capitulum of the following rib is located on the upper posteroexternal angle of the centrum.

The diapophyses are rather large and the subpyriform facet for the tuberculum of the corresponding rib slopes obliquely downward and inward. The prezypagophysial facets are ovoidal in outline, elongated anteroposteriorly (17 mm.), closely approximated to one another, and slope very slightly from outer to inner margins. The postzygapophysial facets are narrow (maximum width 9 mm.), elongated anteroposteriorly (20 mm.), and slope slightly toward inner margins.

The neural spine is broken off above the base and the backwardly projecting dorsal portion of the neural arch is relatively wide posteriorly (28 mm.). The anterior edge of each pedicle of the neural arch is nearly vertical, while the posterior edge slopes upward and forward. The neural canal is narrow and high.

The eighth dorsal (pl. 15, fig. 5) has incomplete metapophyses, the neural spine is imperfectly preserved, and the postzygapophysial facets are broken off.

The interval between the inner margins of the prezygapophysial facets appears to have exceeded that of the fourth dorsal, the neural canal is also wider (22.5 mm.), the backwardly projecting dorsal portion of the neural arch is very narrow, and the width of the posterior face (pl. 15, fig. 8) of the centrum is approximately the same as the anterior face.

The centrum is slightly longer (45 mm.) than broad (41.5 mm.), its ventral keel is rounded, and its lateral surface curves concavely from end to end. The deeply depressed dorsal surface of the centrum is divided longitudinally by a thin ridge.

The diapophyses (or coalesced diapophysis and merapophysis of Abel, 1931) have a deep ovoidal depression on the anterior surface and a similar slightly shallower depression on the posterior surface. The subpyriform lateral facet for the head of the corresponding rib is concave and projects below the dorsal surface of the centrum.

The neural canal is somewhat ovoidal in outline (pl. 15, fig. 2). Although the anterior and posterior edges of the neural spine are eroded, it would appear that it was directed nearly vertically and that it did not slant backwards.

CAUDAL VERTEBRA

With the exception of the distal portion of the neural spine, the metapophyses, the transverse processes, and a portion of the right side of the anterior epiphysis, this caudal (pl. 15, fig. 3) is in a fair

state of preservation. Judging from the dimensions of the centrum and the shape of the neural spine, it seems to be the sixth in this series.

The lateral surfaces of the centrum (pl. 15, fig. 6) are depressed above and below the transverse processes. The convex anterior and posterior surfaces of the centrum appear to have been of nearly equal width. Between the anterior and posterior descending processes the ventral surface of the centrum is deeply depressed and two small foramina are located near the middle of this ventral groove. The posterior facets for the chevron bones are placed obliquely on the posterior surfaces of the large descending processes, but unfortunately the surfaces where the anterior facets were located are eroded.

The right transverse process was broad (36 mm.) at the base and the basal foramen is minute; the corresponding foramen on the left transverse process is normal in size. The pedicles of the neural arch are relatively broad (minimum anteroposterior diameter of right, 31.5 mm.) in comparison to the length of the centrum (58 mm.), and the neural spine is slightly wider near its base than the pedicle. The narrow neural canal measures 14 mm. in height anteriorly.

MEASUREMENTS OF VERTEBRAE (IN MILLIMETERS)

	D.4	D.8	Ca.
Greatest anteroposterior diameter of centrum	38. 5	45. 0	58. 0
Greatest vertical diameter of centrum anteriorly	32. 5	35. 5	50. 0
Greatest transverse diameter of centrum anteriorly	33. 5	41. 0	50. 0
Greatest vertical diameter of neural canal anteriorly	34. 5	29. 5	14. 0
Greatest transverse diameter of neural canal anteriorly	19. 0	23. 0	4. 0
Least anteroposterior diameter of pedicle of neural arch	16. 0	21. 0	29. 0
Distance across vertebra between outer ends of diapophyses	68. 0		
Distance across vertebra between outer ends of transverse processes		75. 5	71.+
Greatest distance between outer margins of prezygapophysial facets	28. 0		
Greatest distance between outer margins of postzygapophysial facets	28. 0		

RIB

The neck of the first rib on the left side is flattened, relatively deep, and bears an elongated or ovoidal capitular facet at the extremity. The larger tubercular facet is also elongated and is subtriangular in outline. The rather wide and flattened shaft terminates in a slightly thickened distal end. Between the tuberculum and the angle the widened dorsal edge of the shaft slopes obliquely from posterior to

anterior margin. Behind the level of the tuberculum the shaft is abruptly bent downward.

The length of this rib in a straight line from tuberculum to distal end of shaft is 165 mm.; greatest breadth of shaft at angle, 35 mm.; and greatest breadth of shaft near middle of its length, 26 mm.

III. IDENTITY OF TRETOSPHYS GABBII (COPE)

During the year 1868, Prof. E. D. Cope received a miscellaneous collection of vertebrae and other skeletal fragments from a Maryland correspondent, Dr. James T. Thomas. Included among these bones was the caudal vertebra on which Cope based the name *Delphinapterus gabbii*. Cope did not designate a precise locality. From residents of Charles County information has since been obtained relative to the location of the residence of Dr. Thomas near the Patuxent River. Although it can not now be stated with certainty, in all probability this type vertebra and the other specimens described by Cope were found by slaves who were digging shell marl on the De la Brooke estate.

No specimens referable to this species were received by the United States National Museum until 1918, when Dr. Rodney B. Harvey excavated the specimen hereinafter described in the cliff south of Chesapeake Beach, Md.

Genus *Tretosphys* Cope

Tretosphys Cope, Proc. Acad. Nat. Sci. Philadelphia, vol. 20, p. 186, 1868.

Genotype: *Delphinapterus gabbii* Cope. (Designated by Hay, U. S. Geol. Surv. Bull. 179, p. 591, 1902.)

Diagnosis: Mandibles strong, with symphysis firmly ankylosed, V-shaped in cross section, attenuated gradually toward anterior end and with anterior half of its length bowed upward; lateral surfaces of symphysis rugose; opposite free hinder portions of mandibles form an acute angle at level where they ankylose as symphysis; 14 teeth located on left mandible anterior to posterior end of symphysis; 2 teeth directed forward and upward at extremity of each ramus; roots of other teeth on symphysis implanted obliquely in alveolae, which slope more noticeably backward than inward; alveolae relatively large, closely approximated, those in right ramus larger than those in left ramus, and consequently teeth in the two rows were not opposite; teeth single rooted; anterior teeth have relatively smooth enamel on anteroposteriorly flattened crowns that curve inward and backward; teeth from near middle of tooth rows have enamel on outer surface of crown ornamented with fine striae; crowns

of posterior teeth variable, but wider anteroposteriorly in proportion to height; some have a fairly large accessory cusp with denticulated cutting edge at base posteriorly, others have three or more tubercules, one above the other, and many have a rugose or coarsely sculptured internal face.

Basihyal almost hexagonal; thyrohyals dilated beyond basal constriction and tapering toward extremity; stylohyal somewhat flattened and curved slightly from end to end; olecranon process of ulna elongated, with deep notch between it and shaft; dorsal and lumbar vertebrae characterized by high neural canals.

Tretosphys gabbii (Cope)

PLATES 17–21

Delphinapterus gabbii Cope, Proc. Acad. Nat. Sci. Philadelphia, vol. 20, p. 191, 1868.

T[retosphys] gabbii Cope, Proc. Acad. Nat. Sci. Philadelphia, vol. 20, p. 191, 1868.

TYPE SPECIMEN (USNM 11234): An imperfectly preserved anterior caudal vertebra that lacks the neural spine and transverse processes. Collector, James T. Thomas.

MEASUREMENTS OF TYPE SPECIMEN (Case, 1904, p. 9)

Anteroposterior diameter of centrum	52. 6 mm.
Transverse diameter of anterior face of centrum	40. 7
Vertical diameter of anterior face of centrum	37. 4
Transverse diameter of neural canal at base	4. 3

HORIZON AND LOCALITY: Probably excavated by slaves of Dr. Thomas in marl bed on De la Brooke estate, about 1 mile east of Patuxent, Charles County, Md. Calvert formation, upper Miocene.

REFERRED SPECIMEN (USNM 10709): Ankylosed symphysis of mandibles, length 170 mm.; section of the left mandible posterior to symphysis, with 3 teeth, length 66 mm.; section of right maxillary, with 3 teeth, length 138.5 mm.; 2 pieces of premaxillary; 54 detached teeth; basihyal, left thyrohyal, and incomplete left stylohyal; fourth dorsal and an anterior lumbar vertebrae; left ulna; proximal end of radius; 1 carpal; 1 phalange; and 4 rib fragments. Collector, Dr. Rodney B. Harvey, June 23, 1918.

HORIZON AND LOCALITY: In a yellowish white diatomite with considerable content of fine grained sand, presumably referable to Zone 5, about six feet above the oyster (*Ostrea percrassa*) layer, one-half mile south of old Chesapeake Beach wharf (and 135 yards south of Marinelli's place), Calvert County, Md. Among the diatoms recognized by Paul S. Conger in the matrix are: *Coscinodiscus obscurus* A. Schmidt, *Coscinodiscus lewisianus* Greville, *Coscinodiscus perforatus* Ehrenberg, *Actinoptychus undulatus* (Bailey?), *Actinocyclus monili-*

formis Ralfs, *Melosira sulcata* Ehrenberg, and *Sceptroneis caduceus* Ehrenberg. Calvert formation, upper Miocene.

MANDIBLES

The mandibles (pl. 17, fig. 1) are represented by a fairly complete symphysis and a 69 mm. fragment of the left ramus posterior to the hinder end of the symphysis. The upward curvature of the anterior end as well as the greater length of the symphysis distinguish these mandibles from those of *Delphinodon dividum.* Since the braincase and the hinder portions of both mandibular rami were not preserved, no estimate can be made of the total length of either mandible. Other Calvert Miocene porpoises, with the exception of *Zarhachis, Schizodelphis, Eurhinodelphis,* and related forms, have 11 to 14 teeth located in each mandibular ramus behind the fork of the symphysis. On this basis each mandible may have held from 25 to 28 teeth.

Although the symphyseal portion of the mandibles is firmly ankylosed, a narrow groove extending the length of the symphysis marks the contact of the opposite rami dorsally and ventrally. The anterior half of the symphysis is bowed upward and its anterior end is obliquely truncated. There are 16 alveolae in the left mandibular ramus, of which 14 are located on the symphysis. The alveolae diminish in size toward the anterior extremity, although those in the right mandible average larger. Two teeth were directed forward and upward at the extremity of each ramus. The largest alveola (the fifth counting forward from hinder end of symphysis) in the right mandible measures 9.5 mm. anteroposteriorly and 8 mm. transversely. At the alveolar border the alveolae on the symphysis are separated by thin septal walls and the alveolae in the two series are not located opposite one another.

The dorsal surface of the symphysis is relatively flat transversely to and including the anterior end, the interval between opposite alveolae being 20.5 mm. at the level of the third pair of teeth (counting forward from posterior end of symphysis) and 13 mm. at level of 11th pair of teeth.

The largest nutrient foramen is located on the outer surface of the left mandible (pl. 17, fig. 2) 14 mm. below the rim of the fourth alveola (counting forward from posterior end of symphysis). Smaller foramina are discernible below the sixth and seventh alveolae. A larger foramen is located on the right and left mandibles below the 11th alveolae within 3 mm. of the midline of the ventral face of the symphysis. Short grooves extend forward from each of these foramina. A cross section of the symphysis resembles a wide, open V.

The depth of the left mandible in its present condition at the posteriormost alveola was approximately 40 mm., although crushing may have distorted the ramus to some extent. The opposite free posterior portions of the mandibles come together at an acute angle (25°) at the symphysis.

MEASUREMENTS OF MANDIBLES (IN MILLIMETERS)

Greatest length of ankylosed symphyseal portion of mandibular rami	147. 0
Greatest length of right mandibular ramus, including symphysis	170. 0
Transverse diameter of ankylosed symphysis at posterior end	43. 0
Vertical diameter of ankylosed symphysis at level of posterior end	27. 0
Transverse diameter of ankylosed symphysis 20 mm. behind anterior end	28. 0
Vertical diameter of ankylosed symphysis 20 mm. behind anterior end	23. 0
Interval containing 14 alveolae in left mandibular ramus (counting forward from hindmost)	146. 0

ROSTRUM

The rostrum (pl. 17, fig. 3) is represented by a 136 mm. piece of the posterior palatal portion of the right maxillary, a 70 mm. piece of the right premaxillary, and a 115 mm. piece of the left premaxillary. The roots of three teeth are in place in the maxillary, but lack crowns. On this portion of the maxillary there were at least six alveolae anterior to these teeth and three alveolae posterior to them. Inasmuch as the inner margin of this right maxillary is complete, the width of the rostrum at the level of the anterior ends of the palatine bones cam be estimated as approximately 85 mm. The tapering maxillary fragment also indicates that the palate narrowed rapidly anteriorly.

TEETH

These teeth (pls. 20, 21) are somewhat similar to those of *Delphinodon dividum* described and figured by True (1912, pp. 171–174, pl. 19, figs. 1, 2; pl. 26, figs. 1–20). They differ in part from the teeth of *D. dividum* in being larger and in having the crowns of the long anterior teeth more noticeably compressed anteroposteriorly. Further comparison is not necessary with most of the species described from the Miocene of either Maryland or Virginia.

There are 54 fairly complete teeth, though none are entirely so. The enamel on the inner surface of the crowns is somewhat variable in ornamentation. Nevertheless, this ornamentation of the enamel on the crown, with other characters, serve as an indication of the position of the teeth in the jaws. They group themselves naturally as follows:

Eighteen are posterior teeth with accessory cusps and tubercules, of which three were in place in the mandible. On most of these teeth the apex of the crown curves inward and backward. Five teeth, presumably from near the middle of the tooth rows, have the enamel on the outer surface of the crown ornamented with fine striae. There are 28 anterior teeth having crowns with nearly smooth enamel, although a number of them have a fine, vertically directed carina on the outer surface.

The anteriormost teeth (pl. 21, figs. 7, 8) are characterized by an elongated root, high anteroposteriorly compressed and inwardly recurved crown, and several irregular striae on the basal half of the outer face.

A few of the posterior teeth (pl. 20, figs. 2, 6; pl. 21, fig. 2) possess a thin denticulated and curved carina on the external face of the crown extending to or almost to apex of the main cusp in addition to one or more accessory tubercles on the posterior face as well as a row of fine denticles. Other posterior teeth (pl. 20, fig. 4; pl. 21, fig. 3) are characterized in part by the presence on the posterior face of a fairly large accessory cusp that has a denticulated cutting edge and one or more smaller tubercles. This posterior cusp varies considerably in size and shape, but is set off sharply from the main cusp of the crown. At least three of these teeth (pl. 20, fig. 7) have three or more small tubercles, one above the other, on the posterior cutting edge. One tooth has a well defined and distinct cusp above the base of the crown on both the anterior and posterior faces. The ornamentation of the enamel on the inner face of the crown of these posterior teeth (pl. 21, figs. 3–5) is rugose to a varying degree. On most of these teeth the rugosities on the enamel of the inner face terminate about 2 mm. above the base of the crown and are arranged in more or less vertical striae, of which there are on some teeth five or six. On others there is a less definite arrangement of these minute denticles. Several teeth have the enamel (pl. 20, fig. 3) on the inner face of the crown ornamented with minute denticles, the sculpturing being rather coarse above the relatively smooth base of the crown. The enamel on the outer face of the crown is either relatively smooth or rather faintly striated. The teeth located near the posterior end of the tooth rows have shorter and wider crowns than the anterior teeth, and the apical portion of the main cusp is curved either backward or inward.

There is an evident transition to a few intermediate teeth (pl. 21, figs. 1, 6). On these teeth the development of the tubercles is much less obvious, the crown is longer and differently curved as well as compressed or flattened in an anteroposterior direction. The enamel on the crowns of most of these teeth is somewhat smoother than on the posterior teeth and the crowns are longer and rather slender.

The outer face of the crown has two or more obliquely directed striae that do not extend to the apex of the main cusp. Two teeth (pl. 20, fig. 2) have a lightly denticulated carina on the posterior face of the crown and a small tubercle at the basal angle; the enamel is smooth, not rugose. The external carina does not bifurcate on either tooth.

As regards most of the anterior teeth, the crowns are anteroposteriorly flattened, the more or less conical apices of the main cusps are incurved, and the enamel is rather smooth internally. The anterior and posterior faces are flat, as if the adjoining teeth were crowded or touching one another in the tooth row. On some of these teeth there is one long and occasionally two or more shorter striae on the outer face of the crowns curving in the direction of the apex.

Immediately below the enamel on the base of the crown and above the enlargement, the root on some of the teeth is slightly constricted. The tapering and variously shaped roots of most of the teeth are more or less curved and most of them are strongly bent backward near their extremities. The majority of these teeth have the apices of the crowns, as well as some of the cusps, well worn. On some of the teeth, portions of the enamel surface were chipped off during excavation, and on others the enamel was worn off prior to burial.

A short section of the left mandible has three molars in place, the posterior one being probably the last of the series and the smallest. This tooth has the summit of the crown broken off, but it is decidedly smaller than either of the other two. The crown was small and no cusps were present. The two teeth in front of this tooth, each of which has the apex of the main cusp worn off, had small curved crowns with a well defined cusp on the posterior face of the crown. The second tooth possesses, in addition, four minute tubercles on the anterior face, and the third tooth has a cluster of tubercles on the internal face.

A 136 mm. section of the maxillary has three teeth in place, but all three have the crowns broken off. These three teeth occupy an interval of 27 mm. Although the remainder of the alveolae are incomplete, it is evident that eight teeth were located in an interval of 80 mm.

MEASUREMENTS OF TEETH (IN MILLIMETERS)

	Anterior (Pl. 21, fig. 7)	Anterior (Pl. 21, fig. 8)	Median (Pl. 21, fig. 6)	Posterior (Pl. 20, fig. 6)	Posterior (Pl. 20, fig. 2)	Posterior (Pl. 20, fig. 1)	Posterior (Pl. 20, fig. 3)	Posterior (Pl. 20, fig. 5)	Posterior (Pl. 20, fig. 8)
Greatest length (as preserved)	40.5	38.0	34.3	20.0+	26.3	23.8+	26.0+	26.0	23.5+
Length of root	29.2	27.0	25.0	10.5+	16.5+	15.5+	18.0	18.5	16.4+
Greatest diameter of root	8.2	7.8	8.3		5.4	6.0	7.2	6.0	7.2
Height of crown	11.3+	10.0	8.5	10.0	9.5	7.7	8.0	7.8	7.7
Greatest anteroposterior diameter of crown	5.8	5.5	6.2	6.0	5.4	6.0	7.5	7.4	6.0
Greatest transverse diameter of crown	6.9	6.8	6.8	5.8	6.0	6.0	6.5	6.0	6.7

HYOID BONES

The basihyal, the left thyrohyal, and the portions of the left stylohyal were associated with pieces of the skull. These hyoid bones resemble somewhat those of *Delphinodon dividum* (True, 1912, pl. 25, figs. 5, 18).

The central basihyal (pl. 18, fig. 1) is almost hexagonal, rather thin dorsoventrally, and dorsally exhibits a concave curvature from side to side. The ventral surface is raised transversely to form a poorly defined ridge. The ceratohyals were not preserved but were attached to two short irregular projections on the anterior border.

The rather broad and dorsoventrally compressed lateral wings (thyrohyals), which were not ankylosed to the basihyal, curve upward and backward but are not bent downward distally. The left thyrohyal (pl. 18, fig. 2) is thickened at the base where attached to the basihyal, dilated medially, more or less flattened on the ventral face, and tapers toward the extremity.

The left stylohyal (pl. 18, fig. 3) is represented by five fragments, which, when fitted together, indicate a length of 105 mm. It is widened near the middle and curved slightly from end to end. The anterior face is rounded and the posterior face is compressed, imparting a somewhat ovoidal shape to the stylohyal in cross section near the middle of its length. The rugose, dorsoventrally compressed distal end of the stylohyal normally fits into a depression on the ventral border of the exoccipital, and the elliptical proximal end has its long axis at right angles with the shaft of the bone. At 35 mm. from the proximal end, the stylohyal was at least 12 mm. thick.

MEASUREMENTS OF THE HYOID BONES (IN MILLIMETERS)

Greatest anteroposterior diameter of basihyal	45. 0
Greatest transverse diameter of basihyal	56. 0
Greatest length of left thyrohyal	81. 0
Greatest width of left thyrohyal beyond base	28. 0
Greatest length of stylohyal	105.±
Greatest width of stylohyal	19. 0

VERTEBRAE

Two vertebrae which are characterized by unusually high and narrow neural canals were found associated with the mandibles and other skeletal elements. One of them is an anterior dorsal vertebra (pl. 19, fig. 1), possibly the fourth or the fifth. This vertebra differs from the corresponding dorsal vertebrae of *Delphinodon dividum* in having a relatively high and narrow neural canal and a relatively longer centrum (length, 35 mm.) as compared to its width anteriorly

(33 mm.). The ventral surface and the lower portion of the right side of the centrum is missing, the hinder portion of the left diapophysis is broken off, and the neural spine is incomplete. The posterior surface (36 mm.) is slightly wider than the anterior surface (33 mm.) of the centrum, the prezygapophysial facets are flattened and slope slightly from the external to the internal margins, the long axis of the facet for the tuberculum on the diapophysis is nearly horizontal, and the facet for the capitulum of the following rib is located on the centrum at the upper posteroexternal angle. Although the neural spine is broken off above the base, the curvature of the posterior edge suggests that it was quite similar in conformation to that of *Delphinodon dividum*. The backwardly projecting dorsal portion of the neural arch is elongated anteroposteriorly (31 mm.) and relatively wide (approximately 30 mm.). The postzygapophysial facets are elongated anteroposteriorly and slope obliquely downward and inward. The slope from the dorsoexternal margin of the diapophysis to the inner margin of the prezygapophysial facet is more noticeably oblique, as contrasted with the horizontal position of these surfaces of *Delphinodon dividum*. The diapophysis on each side of the neural arch bears a broad ovoidal articular facet for the tuberculum of the corresponding rib. The pedicles of the neural arch slope obliquely upward and forward. The deeply concave lateral surface of the centrum is continuous with the depressed outer face of the pedicle of the neural arch. The epiphyses are relatively thin, firmly ankylosed, and concave centrally. The dorsal surface of the centrum is depressed and a minute foramen is located on each side of the thin longitudinal median ridge. The other vertebra is an anterior lumbar (pl. 19, fig. 2) that lacks the anterior epiphysis, transverse processes, metapophyses, and the entire neural spine with the exception of the anterior basal angle. The centrum is longer than broad, its ventral keel is quite sharp and curves concavely from end to end, and the epiphyseal ridges radiate outward from the center of its concave anterior and posterior ends. The transverse processes were approximately 29 mm. broad at the base.

The pedicles of the neural arch are broad (minimum anteroposterior diameter 24.5 mm.), rather flat externally, with concave anterior and posterior margins, and slightly inclined forward. Above the level of the transverse process, and for the most part posterior to the hinder margin of the pedicle of the neural arch, the lateral surface of the centrum is depressed to form a fairly large shallow concavity. Below the transverse process the lateral surface of the centrum is markedly concave from end to end.

The neural canal is narrow and rather high. The dorsal surface of the centrum is depressed medially, and also laterally on each side of the median thin longitudinal carina.

The type is an anterior caudal vertebra, probably the second or third, that lacks the neural spine and the transverse processes except for their basal portions. The anteroposterior diameter of the centrum (52.6 mm.) is greater than its transverse width anteriorly (40.7 mm.). The vertical diameter of the anterior face of the centrum is 37.4 mm. Viewed from the side the lateral surface of the centrum is seen to be depressed between the base of the transverse process and the base of the pedicle of the neural arch, and the ventral profile is markedly concave. On the ventral surface of the centrum two parallel ridges bound a longitudinal groove approximately 8 mm. in width. Each of these ridges is widened posteriorly for articulation with the corresponding chevron bone. A shallow groove extends backward from near the anterior epiphysis above the base of the transverse process but becomes indistinct posterior to the middle of the latter. The basal portions of the transverse processes furnish some indication of their conformation. At the base, the right transverse process is approximately 28 mm. wide. When complete, these transverse processes may have resembled those of the corresponding vertebrae of *Delphinodon dividum*. The neural canal was narrow and rather low, about 8 mm. in height. The pedicles of the neural arch are flat externally, and at the base occupy less than half the length of the centrum. The epiphyses are relatively thin, firmly ankylosed to the centrum, and concave centrally.

A posterior dorsal vertebra (pl. 19, fig. 3), presumably the ninth in the series, that agrees with *Tretosphys gabbii* in size and general characteristics was found by Norman Boss during August 1913 in Zone 11 four feet above the shell band (Zone 10), 1½ miles south of Chesapeake Beach, Calvert County, Md. This vertebra lacks both epiphyses, and the transverse processes and the metapophyses are incomplete.

The posterior surface of the centrum is approximately the same width as the anterior surface, the metapophyses are rather short and slender, and the prezygapophysial facets are reduced in size. The neural spine is rather broad near base (35 mm.), and commencing about 25 mm. above the level of the metapophyses tapers rapidly to extremity. The pedicles of the neural arch are rather broad, and are not noticeably inclined forward. The centrum is longer than broad. Below the transverse process the lateral surface of the centrum is concave from end to end and the ventral surface is pinched-in to form an anteroposterior ridge. The dorsal surface of the centrum is depressed medially, and also laterally on each side of the median

thin longitudinal carina. In height and shape the neural canal of this vertebra conforms to its position between the anterior dorsal and the anterior lumbar vertebrae.

MEASUREMENTS OF VERTEBRAE (IN MILLIMETERS)

	Anterior dorsal	9th dorsal	Anterior lumbar
Greatest anteroposterior diameter of centrum	35. 0	41. 5 [2]	51. 5
Greatest vertical diameter of centrum	29. 0 [1]	28. 5 [2]	36. 5 [3]
Greatest transverse diameter of centrum	33. 0 [1]	35. 5 [2]	37. 5 [3]
Greatest vertical diameter of neural canal anteriorly	34. 0	32. 5	22. 0
Greatest transverse diameter of neural canal anteriorly	27. 0	18. 5	17. 0
Least anteroposterior diameter of pedicle of neural arch	13. 0	23. 5	24. 5
Distance across vertebra between outer ends of diapophyses	68. 0		
Distance across vertebra between outer ends of transverse processes		56. 0+	
Greatest distance between outer margins of prezygapophysial facets	36. 0		
Greatest distance between outer margins of postzygapophysial facets	29. 5		

1, anteriorly; 2, both epiphyses missing; 3, posteriorly.

FORELIMB

The forelimb is represented by the left ulna, an incomplete proximal end of the radius (pl. 18, fig. 5), one carpal bone (pl. 18, fig. 6), and one phalange (pl. 18, fig. 7). On the proximal end of the radius, the articular surface for the humerus is depressed medially and rounded off internally and the shaft is compressed from side to side, but the facet for articulation with the ulna is broken off. The length of the phalange is 33 mm., the minimum anteroposterior diameter of the shaft 20 mm., and the thickness 7 mm. The measurements of the carpal bone are: Transverse diameter, 27 mm.; vertical diameter, 24.5 mm.; and maximum thickness, 13 mm.

ULNA

The shaft of this left ulna (pl. 18, fig. 4) is quite straight, not noticeably compressed from side to side, and almost elliptical in cross section near the middle of its length. Although the distal end is broken off, the curvature of the anterior and posterior faces indicates considerable expansion distally. The posterior edge of the shaft is rather sharp, while the somewhat rounded anterior face has a shallow groove commencing about 15 mm. below the radial facet and becoming deeper distally. The olecranon is rather large and well developed, pointed dorsally and prolonged ventrally, and its posterior edge is nearly

straight, differing in these respects from that of *Delphinodon dividum* (True, 1912, pl. 25, fig. 4). The sigmoid cavity is rather large, the narrower dorsal portion being bent almost at right angles to the broader ventral articular surface. On the anterior face of the shaft and contiguous with the sigmoid cavity there is a deep facet with a prominent knob at its lower edge for articulation with the radius.

Measurements of ulna (in millimeters)

Greatest length of ulna	104.+
Width of ulna near middle	21. 5
Thickness of ulna near middle	13. 5
Length of olecranon process	44. 5

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U. S. GOVERNMENT PRINTING OFFICE: 1955